JANUARY 5, 1961



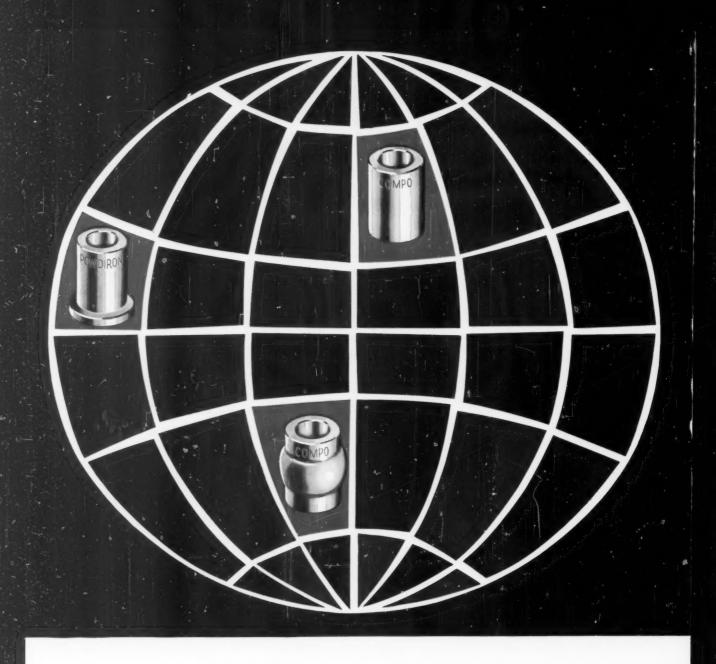
DESIGN

A PENTON PUBLICATION L. BIWEEKLY

Mr. Stevens Rice university and Michigan And Arbor, Michigan

Rolling

Contents, Page



Improving the best is a Bound Brook habit

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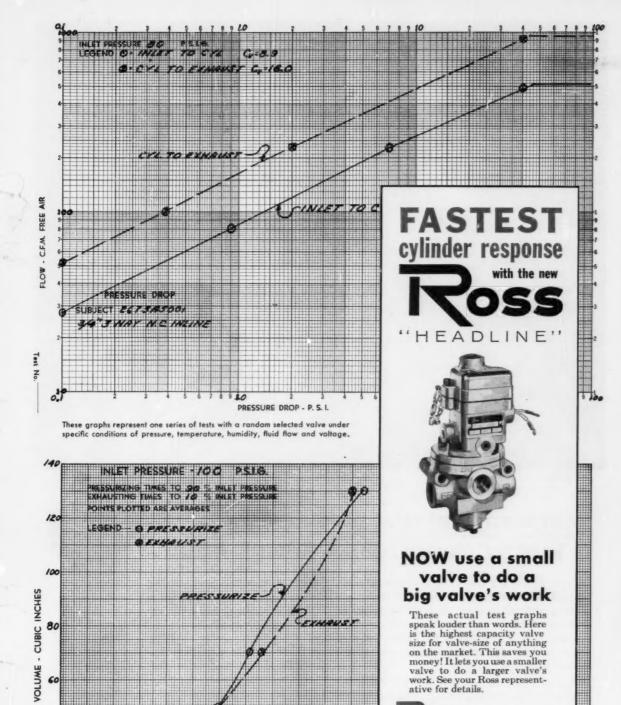


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January 5, 1961

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RESPONSE TIME-SECONDS

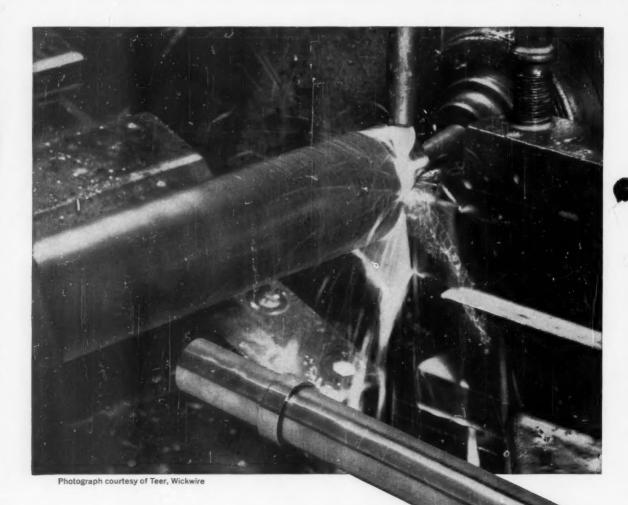
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RESPONSE TIME



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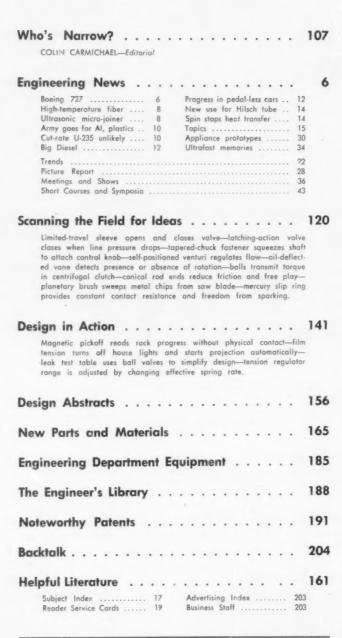
COPPERWELD
STEEL COMPANY

ARISTOLOY STEEL DIVISION - 4017 Mahoning Ave., Warren, Ohio - EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.



Front Cover: All set to operate is the machinery that artist George Farnsworth has set up for cold rolling a shaff fillet. Taking their turn at fillet rolling, coauthors Walter Egger and Gerald Diamond present a detailed design view of the process on Page 112.

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	RODNEY R. ADLER—Highlights of an integrated design and manufacturing system that played a key role in the introduction of mass production methods.
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Anaconda takes to the road with ideas for greater values and higher productivity

We're in the market with ideas. Ideas for doing new jobs-like making transistor bases and fluid-cooled conductors. Ideas for doing present jobs betterhelping you match the metal to the job more precisely so that you can offer equal or greater value and reduce total costs.

These ideas are embodied in Anaconda's line of copper, brass, and bronze mill products, the broadest in the industry-and in the vast pool of experience and technical knowledge of Anaconda men.

To put these ideas to work we've taken to the road with a traveling value-analysis clinic, stopping in industrial centers all over the country. We've a truckload of displays representing our principal products to serve as starting points for discussions of the ideas. We're detaching specialists, technical men, mill men, executives to discuss and explain the ideas with all manufacturers who can attend the clinics.

We're also busy generating new ideas in an aggressive research and development program. And we plan to make available soon small, balanced valueanalysis teams to go out in the field and work with individual company organizations-make specific suggestions and recommendations regarding materials, fabricating methods, design, etc.

Anaconda is on the move. If you have problems in which you think a new approach might help-call your Anaconda American Brass representative. Or write: Anaconda American Brass Company, Waterbury 20, Conn.



January 5, 1961

COPPER-BRASS-BRONZE NICKEL SILVER MILL PRODUCTS

Anaconda American Brass Company

DESIGN ENGINEERING NEWS



Boeing's 727: Jet-Age Tri-Motor

FIRST of a new generation of U. S.-designed jet transports, Boeing's forthcoming 727 is designed specifically for short-haul service. Powered by three rearmounted turbofan engines, the new airliner will require less field length for takeoff than comparable turboprop aircraft manufactured in this country. Through-stop performance of the "junior" jet will be enhanced by fast turnaround equipment, including integral passenger stairways.

Aft engine arrangement on the 727 puts two jets outside the fuselage; the third is cowl-enclosed and suspended from a beam inside. Air duct feeding the third engine originates at the base of the vertical fin.

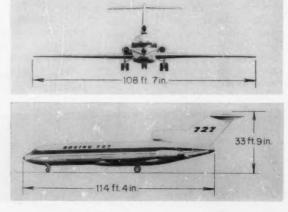
Leading-edge slats, first used by Boeing in the XB-47 stratojet (bomber), give the 727 effective low-speed performance. They extend forward and down from the upper leading edge of the wing at low speeds, forming a slot, and retract onto the wing during cruising flight. To further enhance low-speed performance, the craft's vertical fin is surmounted by variable-incidence horizontal stabilizer and elevators. The fin is 45 in, thick at its forward attachment point.

Scheduled to go into airline service sometime in 1963, the 727 is shorter and less hefty than the 707, but is nonetheless a big airplane. It has the same fuselage width as the larger craft, putting it on equal footing as far as passenger luxury is concerned,

Permission to use the patented three-engine configuration was obtained by Boeing from Sud Aviation, French builder of the Caravelle.

Size and Performance: 727 vs. 707

	727	707-220
Gross weight (lb)	142,000	248,000
Wingspan (ft)	108.5	130.8
Length (ft)	114.3	144.5
Thrust, max (lb)	$14,000 \times 3$	$17,500 \times 4$
Speed (mph)	550-600	550-630
Range, max (miles)	1700	4000
Passenger capacity	70-114	100-179



Third Jower

REPORT NO. 12,108 OILGEAR HOLD-DOWN AND LIFT VSTEMS

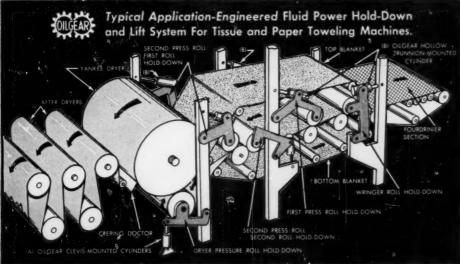
From Oilgear Application-Engineering Files

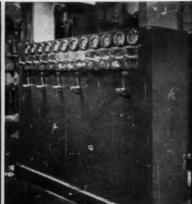
HOW DILGEAR HOLD-DOWN AND LIFT SYSTEMS INCREASE ROLL LIFE-IMPROVE PRODUCT QUALITY USER: Scott Paper Company, Chester, Pa.; Everett, Wash.; Mobile, Ala.; Fort Edward, N.Y.

PROBLEM: To supply hold-down and lift systems for rolls on paper machines, paper coating machines, super calendars, laminating and similar processing machines - that can be accurately controlled from a simple remote control panel.

USER REQUIREMENTS: 1. Provide constant, uniform, preset roll pressures. 2. Smooth lowering and/or forcing of pressure rolls downward to avoid damage, such as fracturing or flatting. 3. Fast, easy, positive selection of such functions as "Lower," "Hold Down," "Release,"

"Lift." "Hold Up," "Off." 4. Accurately, infinitely vary the pressure on either end of each roll independently over a wide range, at any time, to balance the opposing forces created for most efficient machine operation and product quality. 5. A direct-reading, constant, visual indication of the pressure and force exerted on either end of each roll. In addition, the systems must be simple . . . clean . . . easy to install and maintain . . . facilitate replacement of worn rolls . . . trouble-free, dependable, heavy-duty, for continuous, 'round-the-clock





SOLUTION: Oilgear Application-Engineered Hold-Down and Lift Systems consisting of Oilgear Heavy-Duty, Constant or Variable Displacement Pumps that supply Fluid Power to Oilgear "Custom-Quality" Cylinders through separate Oilgear Valves on a remote control panel - provide smooth, positive motion and steady, preset holding pressures. Cylinders can be mounted directly, or through mechanical linkage, to pressure roll bearing ends. Simplicity of pump drive and installation keep machine cost at a minimum. Remote Control Panel provides fast, positive selection of all functions - operator "Hold Up," "Release," "Lower," "Hold Down" - at any time; accurately, infinitely vary pressure on either end of each roll independently, and have constant, direct-reading, visual indication of pressure and force being exerted at bearing ends of each roll.

ONE USER STATES - "The control panel indication is so accurate that a worn, 'off-balance' or out-of-round roll can be readily detected."

Another User Reports - "Oilgear is far superior to other systems...direct gage readings have enabled us to experiment with varying degrees of pressure on the rolls, so that we can operate with less pressure than we hitherto thought feasible. This has resulted in improved product quality and longer roll life."

Tep Phete: One of the Oilgear Hold-Down and Lift System Control Panels as installed with each of Scott Paper Company's two, new tissue machines in their Southern Division Mill, Mobile, Ala.—symbolized in the schematic drawing, left. Daily production from these machines averages 200 tons of Scott's bathroom tissues, toweling and wipers for household and industrial use. Right: A typical Oilgear Heavy-Duty "Power-Pak"—Variable Displacement Pump, electric motor drive, and reservoir base — used with Hold-Down and Lift Systems.

Oilgear is no "stranger" in the paper industry . . . other Oilgear Linear Drives are in operation on pulp log splitters and pulp baling presses. Similarly, the highly efficient, long-life, Oilgear Heavy-Duty Variable Speed Rotary Drives are compiling enviable records on special purpose paper machine sections . . . on complete paper machines . . . on multi-color printing press drives . . . or unwinder and winder drives . . . on laminating and coating machine drives. It's well worth your while to consider Oilgear - "for the lowest cost per year!"

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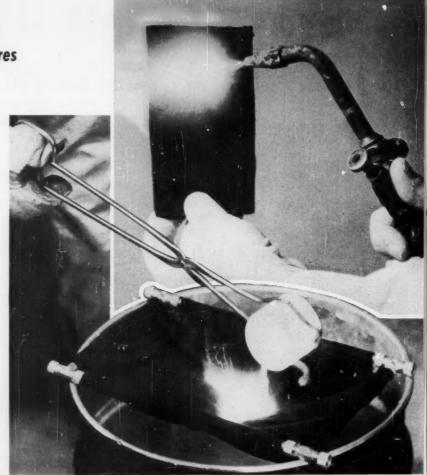
New All-Organic Fiber Stays Flexible at Flame Temperatures

ST. PAUL, MINN.—Plasma-jet temperatures of 18,000 F won't melt an all-organic fiber developed by Minnesota Mining and Manufacturing Co. Woven as a heat-resistant fabric, the new fiber (called Pluton) has potential uses as liners for rocket-motor cases, anti-arc wraps in electrical powerplants, and light-weight protective curtains in buildings, mines, or steel mills.

Worked into laminates reinforced with high-temperature phenolic resins (approximately 50-50 combination), Pluton is suitable for structural parts like missile nose cones. The fiber is entirely free of elemental carbon and conducts very little heat, according to 3M.

Other fibers now under development are designed to give any degree of thermal and electrical conductivity when mixed with hightemperature phenolics.

Ten-ply laminate of fiber (top, right), reinforced with phenolic resin, withstands 5000-F flame, shows exceptionally low conductivity. Molten steel poured into fabric (right) solidifies without burning a hole.

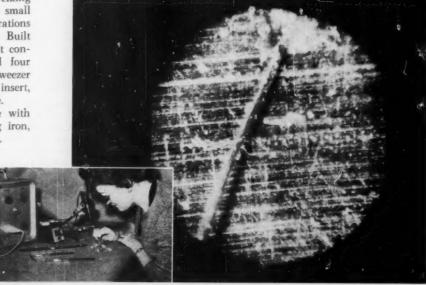


Micro-Joiner Makes Miniature Welds

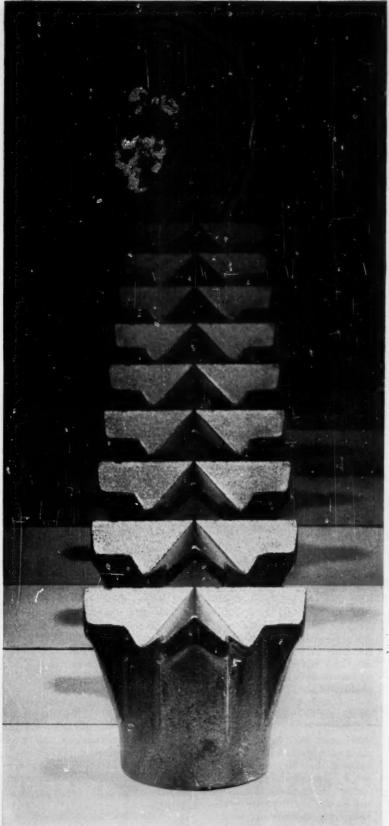
Long Island City, N. Y.—Heatless welding and fluxless soldering of wire leads as small as 0.0001 in. diam are practical operations with a new table-size ultrasonic unit. Built by Cavitron Corp., the micro-joining kit consists of a transducer hand piece and four basic inserts, including attachments for tweezer welds, ball modification of the tweezer insert, spot-welding insert, and a vibrating table.

Micro-soldering without flux is done with a special heating transformer, soldering iron, and attachments for hot-plate soldering.

Microphotograph s h o w s weldment of 0.001-in. copper-plated nickel-alloy wire on 0.003-in. aluminum foil. Operator is using a ball modification of the tweezer-weld attachment. Although any ultrasonic generator can be used, Cavitron will market a unit.



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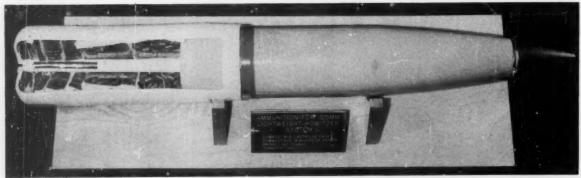


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Army Shoots the Works on Materials

A DISAPPEARING CARTRIDGE case and a frameless trailer are new Army developments made possible by the astute application of materials.

The cartridge case, developed by Picatinny Arsenal and Armour Research Foundation, is completely combustible. Made of plastic, it weighs 1/10 as much as a conventional brass unit. The case was designed primarily for use in tank guns, where it will eliminate two notorious nuisance problems—the litter of hot spent cases rolling around on the floor of the tank's fighting compartment, and noxious gases released inside the turret after each firing.

Army's new frameless trailer is a semi-mounted 2000-gallon tanker. Mounted on a standard ordnance axle assembly and made of aluminum, it carries 500 gallons more than a steel tank assembly of the same weight. Built by Standard Steel Works, North Kansas City, Mo., the trailer is insulated and heater equipped, making it suitable for arctic or desert operation.

Brass reclamation will be a thing of the past for the Army when the plastic cartridge case enters service. Less susceptible to handling damage than a brass case, the plastic version also is safer: It will not explode if hit by bullets or shell fragments.

Frameless tank trailer needs no protective interior lining, as does a steel unit. Built principally of 3003-H 14 aluminum, it weighs 6400 lb, is normally towed by a $2^{1/2}$ -ton tractor.



Cut-Rate U-235 Not Likely, Says AEC

Washington—During the past few weeks, considerable alarm has been sounded in various governmental circles regarding the nuclear capability of certain foreign nations. It was noted, in particular, that several European countries are actively experimenting with the gascentrifuge process to produce weapons-grade (U-235) material.

The following remarks, issued by the U. S. Atomic Energy Commission, tend to play down the situation, while leaving the door open for speculation:

The gas-centrifuge theory calls for uranium in gaseous form (uranium hexafluoride) to be passed through high-speed centrifuges. The slight difference in the weights of U-238 and U-235 isotopes will, theoretically, cause them to separate.

The process is immensely complex, however, because fissionable U-235 constitutes only 0.7 per cent of natural uranium (U-238). The other 99.3 per cent is of no use for weapons.

Biggest advantage of the gascentrifuge process is that it requires very little electrical power in comparison to other processes. Also, a production plant using the centrifuge method could be simply housed and would not be easy to detect.

A review by the AEC of available information on the gas-centrifuge machines built both here and abroad indicates that they cannot be used in a production plant without further development work. Even after substantial improvements have been made, thousands of gas centrifuges probably would be required

to produce enough enriched uranium for one crude weapon per year.

Problems still must be solved before a satisfactory process is possible with the current centrifuges:

 Reliability of the present experimental machines for continuous, long-term service with uranium hexafluoride must be proved.

 A model of the machine satisfactory for mass production of identical units must be developed.

 A method is needed to introduce and remove the gas when the machines are grouped, as they would be in a production plant.

 The auxiliary processes, services, and instrumentation necessary for plant operations have to be determined.

None of these problems is simple to solve, but none is impossible.



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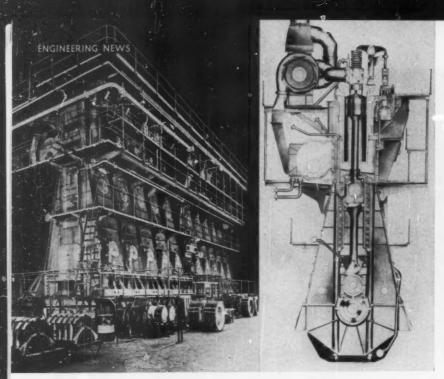




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Danish Diesel Develops 21,000 Bhp

A ten-cylinder, two-stroke marine diesel engine built by Burmeister & Wain, Copenhagen, Denmark, develops 21,000 bhp at 110 rpm. It may be operated at 10 per cent overload continuously and at 20 per cent for limited periods. Cylinder bore is about 33 in.; length of stroke, almost 71 in. At a mean indicated pressure of 135 psi, the output of the turbocharged engine is 165 per cent that of a nonturbocharged model of the same cylinder dimensions. Mechanical efficiency with full turbocharging is as much as 90 per cent. The engine weighs 830 tons.

Deflecting Floorboards Control Experimental Car

DETROIT — An automobile that doesn't need brake or accelerator pedals highlighted a recent demonstration by Bendix Corp. of what's new in automotive developments. Other innovations presented by the company included a new idea in power steering and a split-brake system.

Feet on the Floorboards

It's merely a matter of time before brake and accelerator pedals become as obsolete as the hand crank, Bendix engineers claim. Key to the no-pedal auto is a segmented but completely unobstructed floorboard arranged so that moderate pressure on two of its sections provides accelerating, slowing, and stopping functions. On the driver's side, the floorboard includes two special panels; the right one hooks up to the accelerator and the left to the brakes.

In the experimental car demonstrated, the brake board moves one eight of an inch, and the accelerator moves slightly more than one inch. The system gives the driver a firm-pedal feel, avoiding the possibility of oversensitive controls: The driver must exert the same braking force as in a standard car.

The brake segment of the floor-

board meters a valve that controls flow of fluid to the brakes. A pump in the system provides 2000 psi pressure in an accumulator, and the accumulator maintains braking pressure even when engine and pump are not operating.

If power should fail, increased foot pressure causes the brake "pedal" to move into a well beneath the floorboard. A standard master cylinder goes into operation and the brakes operate as they would on a normal car.

Bendix claims two important safety advantages for the system:

• It cuts down the time required for driver response to danger (he does not have to lift his foot to the brake pedal).

 Pressure developed is more than adequate to operate the brakes, even under the most extreme conditions of brake fade.

Sports-Car Steering

The new steering system gives a standard car the maneuverability of a sports car, according to Bendix engineers. The system, called Varamatic steering, features a variable ratio. In straight-ahead position, the ratio is at its maximum of 22 to 1.

To furnish direct, positive, and

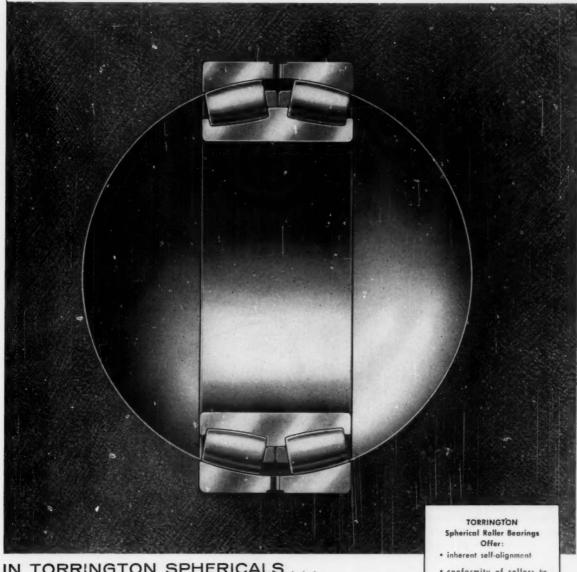
quick car control, and to increase driving ease and safety, the system combines a variable-ratio gear with a power cylinder. It reduces parking and maneuvering turns by 60 per cent, while providing firm, safe steering-wheel feel during highspeed driving.

Bendix spokesmen claim the system may eventually lead to a change in the shape of steering wheels. It makes practical handlebar grips and half wheels similar to airplane controls.

Split Brakes Can't Fail

The new brake system provides a safety factor many times greater than that offered by present car and truck brakes. Bendix designers claim it offers the most effective and practical method of designing for invulnerability to hydraulic leaks.

Unlike ordinary hydraulic-brake components, the master cylinder contains two pistons that operate independently. One piston pressurizes the front brakes, the other provides pressure for the rear. If either of the two independent hydraulic systems should fail, the other one can supply emergency stopping power to the remaining effective brake set.



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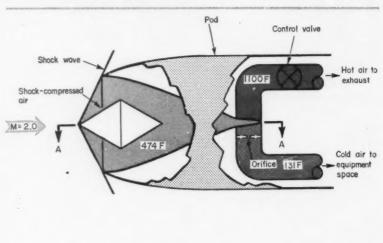
Laboratory Curiosity Tries Out for a Cooling Job

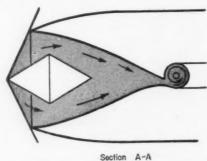
CHICAGO—The Hilsch Tube, an aerodynamic "cream separator" that has long intrigued gas dynamicists, may be the heart of a new aircraft-refrigeration system. It's being developed as an electronic-component cooler by Hallicrafters Co.

The device uses shock compression to centrifugally separate low-energy molecules from an air stream. Air behind the shock is pushed into an inlet resembling that of a ramjet engine. From the inlet, air enters the Hilsch Tube tangentially and is spiralled into a vortex. A strategically placed orifice bleeds off the low-energy (dense) particles for equipment cooling; hot molecules that remain are ducted overboard. A valve in the hot line effectively regulates temperatures downstream of the orifice.

Calculations show the Hilsch Tube can separate out 65 per cent of the inlet air. This low-density (cool) air is more than adequate for the electronic-cooling requirements of aircraft.

Allowing for considerably less than ideal performance, Halli-crafters engineer Richard L. Turner believes the simplicity of the vortex tube promises sufficient savings in weight, space, power, and cost to make the device a strong contender for future aircraft-refrigeration designs in electronic applications.





Compressed air behind a Mach-2 shock wave—at 474-F stagnation temperature—is too hot for direct cooling of electronic equipment. The Hilsch Tube, housing a controlled vortex, centrifugally separates such inlet air into hot and cool streams. Cooler air (at 131 F) is ducted to equipment compartments; hotter air (at 1100 F) is exhausted to atmosphere.

Spin Stops Convection Heat Transfer

ITHACA, N. Y.—While searching for new ways to cool space vehicles, a Cornell University professor and his colleague recently discovered heat transfer by natural convection can be stopped by spin. They are now gathering data with various liquids and are developing a universal formula for calculating convection cooling of any space craft spinning at a given rpm.

The project, undertaken by Cornell's Prof. David Dropkin and Avco Mf_{\(\delta\)}. Corp.'s Samuel Globe, is set up to simulate conditions that will be encountered by vehicles reentering the earth's atmosphere. By spinning cylindrical containers about

a vertical axis, the researchers have generated Coriolis forces that retard heat transfer. The forces, acting on fluid particles that have a horizontal velocity component, deflect streamlines in a direction perpendicular to both the axis of rotation and the direction of particle motion. Dissipation of energy due to flow is checked, closed streamlines are lengthened, and heat transfer by conduction (layers of different densities are in contact for a longer time) "smooths out the hot spots."

Data indicate it is possible to completely stop heat transfer by convection when the proper spin, height of liquid, and liquid flow motion are attained and the "critical heat" is applied. With mercury as the liquid medium, the scientists have succeeded in stopping convection heat transfer at a spin rate of 6 rpm when supplying a heat flux of 1725 Btu per hr per sq ft.

Using a variety of cylindrical containers of different sizes, Professor Dropkin and physicist Globe are conducting experiments with mercury, sodium, sodium-potassium, and other experimental liquid metals. The project, part of an Avco research program on re-entry problems, was initially sponsored by the Air Force. Since much of the work will influence general knowledge on heat transfer, however, the project is now being financed by the National Science Foundation.

Topics

Added detraction for a juke box: Commercials. A patent has been issued for a juke box that dispenses advertising messages until someone gives it a dime to play music.

A variation of seat-of-the-pants flying may show up in the jet cockpit. For aircraft loaded with instruments so numerous they are hard to watch and radios that may be drowned by engine noise, a "touch" system of communication is proposed. In Air Force experiments, trained subjects with vibrators attached to their fingertips have been able to receive processed radio messages. A coding system is used, rather than direct transmission of speech. Accuracy is in the range of 85 to 90 per cent.

After he lands on the moon, a spaceman's first quest is likely to be for a glass of water. All he has to do is find the right kind of moon rocks (some contain 5 per cent water), put them in a container, and focus the sun's heat on them with a mirror. When the temperature of the water in the rocks reaches about 1500 C, it will rise in the form of steam, whereupon it can be caught and allowed to condense, forming potable water. Aerojet-General Corp. scientists who propose the system are confident that the product of such a lunar distillery will be know as (what else?) moonshine.

More mileage is promised to two important items of equipment by ure-thane coatings, according to Union Carbide Chemicals Co. Within a few years, golf balls and men's shoes will receive the protection of this material, which will guard against abrasion, resist dirt, give a long-lasting luster, and protect against chemicals and solvents.

Bulbs on their rims may light the way of 1965 or 1970 automobile wheels to greater safety and beauty. The Goodyear Tire & Rubber Co. is experimenting with translucent tubeless tires made of specially compounded Neothane, a polyurethane rubber. Because this material has a low molecular weight, it can be poured into a mold to form tires. Fabric, splices, and layers of rubber are eliminated. Neothane tires can be dyed to match the car, lighted to glow in the dark.

DRAFTING



Helpful new booklet suggests drafting, engineering shortcuts

Just published—"DRAFTING SHORTCUTS" is a completely new booklet of helpful ideas and aids for engineers, draftsmen and students. It is well illustrated, clearly and logically written. It contains a wealth of time-saving tips to speed both routine and specialized tasks.

The ideas selected were submitted by professionals and judged by an impartial panel of widely recognized authorities on the various topics covered.

As an example, the section covering *Calculating Ideas* includes a simple means of locating stress points on cantilevered beams, also a simple method for retaining fundamental trigonometric relations.

In the section on *Drafting Short*cuts, our editors have come up with topics like a simplified, fast and easy method for drawing gear teeth profiles and a rapid means of showing twisted wire elements. The Engineering Data section covers new, easy-to-use shortcuts to formulas and engineering data.

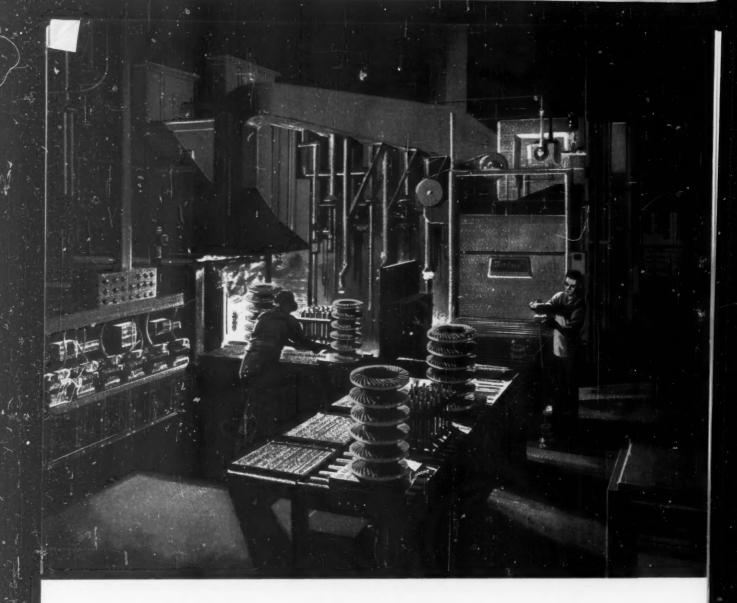
There's a special section devoted to time-saving techniques on the drawing board, too. One of the suggestions on how to make life easier for the draftsman tells how to use a bent paper clip as a variable guide for making section lines.



For your free copy of "Drafting Shortcuts" contact your Post dealer or write today to the Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18, Illinois.



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At your request, our gear engineers would be pleased to describe this process in greater detail and to explain, as well, what our recently expanded facilities can mean in terms of this pledge: "DOUBLE DIAMOND Gears offer the advantages of lower installed cost and economical and dependable service on the job...gears that do credit to your product and reputation."

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Reader Information Service

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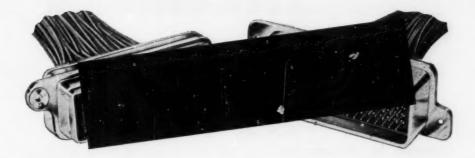
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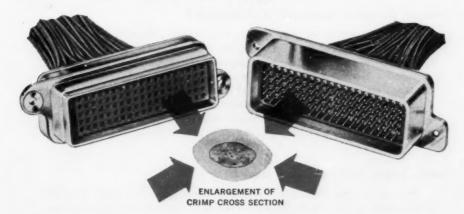
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IT'S THE CRIMP THAT COUNTS! Line 'em up! Look 'em over! They're as much alike as midnight sheep jumping for a sleep-searching count and . . . with good reason! Most of them have a great deal in common — materials, design and construction.

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TRENDS

rehearsal for registration

New aid to engineers preparing for professional registration is offered by the University of California. "Engineering Fundamentals," a correspondence course based on a three-year analysis of more than 100 examinations used by 35 states, is now ready to go. The course—the first offered on a nation-wide basis—is designed to help engineers get ready for closed-book portions of registration examinations.

long-distance diagnosis (people)

Newest of the many new pieces of medical equipment now being engineered is a system that will let a physician give an electrocardiogram in his patient's home. In present experiments, a 3-oz battery-powered transmitter (developed for Lockheed's Polaris missile and Discoverer satellite) is worn about the neck. The device radios the cardiograph to an FM tuner and conventional ECG machine. For longer-range transmission, electrocardiograms may someday be transmitted via telephone lines directly from patient to medical center where computing machines will process and immediately interpret the data.

longer distance diagnosis (spaceships)

When a spaceship starts to sputter, says Halim Ozkaptan, human-factors specialist at Republic Aviation Corp., the crew will radio symptoms down to robot stations on earth. There, computers will digest the information and diagnose the trouble. Tips on how to make repairs will be beamed back seconds after the trouble is reported. An astronaut can't be trusted to do his own troubleshooting for two reasons: He will take too long, and he will be hampered by knowledge that errors could be deadly.

data bonus from a solar flare

The capsule from Discoverer 17 brought home some unexpected dividences. Scheduled to orbit for 50 hr (more than twice the normal time for recoverable vehicles), the satellite was carrying its first biomedical and radiationtest payload. Just before countdown, a high-energy solar storm flared up, lasting the entire time Discoverer was "flying." According to Lockheed scientists who are now studying the capsule, it contains first-hand information on the effect of solar storms on human tissues and structural materials.

off-the-shelf or out of business

More than 90 per cent of the specialty-component manufacturers will disappear from the electronics business within the next ten years, predicts Bernard M. Goldsmith, president, Nytronics Inc. His reason: Customers are demanding standardization. To meet the challenge, designers must anticipate specifications and provide components that cover a broad range of operating characteristics. This can be accomplished by scanning the fields served, not with anticipation of an order, but with knowledge that customers must choose their purchases on the basis of what is available.

radio tunnels in space

Cornell University is studying a novel new possibility for radio communication. According to Prof. Henry Booker, magnetic channels built into the atmosphere may steer high-frequency waves between the northern and southern hemispheres. Path followed by the waves could travel thousands of miles into space. The earth's magnetic field controls the motions of the extreme outer atmosphere, lining up ions into millions of wave guides that run from north to south. Work now going on is designed to map these passageways and see if they will keep message waves from dissipating.

low-power computations

Packard Bell's PB 250 computer needs so little electricity that the company has now adapted it for battery operation. Normally recharged (from a 115-v line) while the computer is in use, the battery can provide power for one hour in case of line failure or in field use. Because the computer can do a tremendous amount of computation in that hour, the battery supply opens new applications for automatic computation, according to Max Palevsky, vice president of Packard Bell Computer.

faster IR for ASM

Another advance has been recorded in development of an operational literature-searching service. The American Society for Metals is now using a commercial general-purpose computer. The equipment, although not specifically designed for information retrieval (IR), was readily programmed for the job, and the computer manufacturer (General Electric) is now designing a tailored searching system around the GE-225 computer.

RELIABILITY
PRODUCIBILITY
STANDARDS
HUMAN FACTORS

Complexity of engineered products—plus costs that continually get out of hand—have added another specialist to a growing list. A "pinchpenny" by profession, his job is to save money through

Value Engineering

- √ The concept has been in existence for about 10 years.
- One of the largest companies in the U. S. is sold on it.
- ✓ Several military establishments are actually saving money with it.
- ✓ Its proponents are set to form a new technical society.
- ✓ But there are also dissenters.

IN 1945, an aircraft carrier cost the Navy approximately \$90 million, submarines delivered for \$5.2 million. The price tag on these items today reads something like \$400 million for the carrier; between \$60 and \$100 million for the submarine. Meanwhile, the weapons budget has not risen by anywhere near this ratio. It follows that any technique promising substantial savings in the design and construction of weapons would be welcomed by the military.

Six years ago, Navy office learned of a new approach to cost cutting caused value engineering. One of the country's largest corporations (and a major defense contractor) was using the technique successfully in the design of many industrial and consumer products.

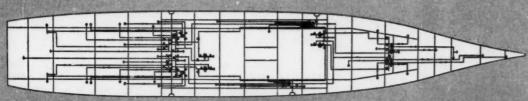
Today, all major Naval Bureaus have active value engineering programs. And since 1956, some 2000 projects have been "value engineered," resulting in savings of \$5 to \$7 million yearly. As savings are reported only for the first year or the first ship, these figures do not represent cumulative savings brought about by changes in specifications and designs. The total figure is estimated at \$40 million.

Despite such favorable results, value engineering, until recently, was not a widely publicized activity.

VE vs. DE

VE is a series of techniques and philosophies, combined into an analytical and efficient approach to cost reduction. It is aimed at the very heart of the problem where cost begins—function.

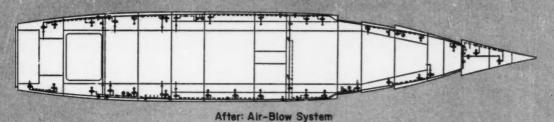
The VE techniques in themselves are not new. Most of them are used every day. What is new, is the co-ordination of many independent steps into one program headed by value-oriented people whose main responsibility is obtaining the necessary function at minimum cost.



Before: Water-Pump System

Water-pump vs. air-blow ballast: A major Naval engagement in value engineering. First in a class of Amphibious Transport Dock ships, Navy's 500-ft LPD-1 harbors landing craft to put troops and equipment ashore. One operating requirement is that the ship must ballast down aft to take on approximately 16 ft of water over the stern gate into the well. This enables landing craft to come aboard for loading and unloading. Original design called for conventional water-pump ballasting system which involved,

among ether things, \$770,000 worth of Ca-Ni salt-water pipe. Value engineers decided that an air-blow system would do the job, despite the fact that no other Naval surface ship had used the technique. Final result: Cost of piping alone was reduced \$530,000 and the air-blow system is frater, simpler (as shown by drawings), and will probably be more reliable. Value engineers also originated 37 other design changes in three months they allotted to the LPD-1, saving \$1.5 million per ship.

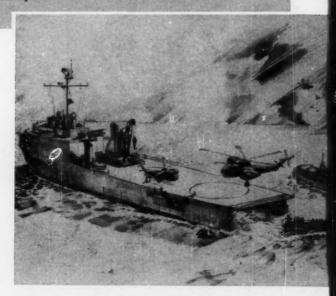


Since all engineers are cost conscious, the valueengineering concept would seem to imply criticism of the working design engineer. None is intended, say VE's.

The engineer who originates the initial design or improves on an existing one is performance oriented, and most of his design work is done with a deadline in mind. Naturally, he gives some thought to economical ways of achieving a function. He also gives thought to whether or not the product can be easily produced. But his primary emphasis is placed on creating a workable design.

Professional Second Guessing

After the design is proved feasible and workable, the value engineer steps in. His job: To achieve the same function and reliability at considerably less cost. The value engineer's job encompasses the whole design from inception to maintenance. He



takes nothing for granted and frequently challenges the specifications themselves, rather than starting from the specifications. For this reason, the value-engineering office is usually placed at a high organizational level . . . to afford access to all management levels. The value engineer must reflect management's viewpoint.

There have been many attempts to place the value-engineering effort in the research stage or into the original design. However, it is generally conceded that at any stage before a workable, producible piece of equipment is designed, the introduction of value engineering adds one more item of compromise for the design engineer. The exception is found in military projects, where R&D, prototype development and production overlap to such

a degree that VE must be in on the R&D stage.

Many critics of value engineering have said that everybody should be doing it, that eventually value engineering will die out as the designer becomes more value conscious. Not so, say VE proponents—not as long as cost is a major consideration. It's an old adage that everybody's responsibility is nobody's responsibility. One of the fundamental principles of management is that when a job needs to be done, assign responsibility for it to one individual. Thus, responsibility for value is primarily the value engineer's. He becomes a specialist and can act as consultant at all stages of design and production as would a metallurgist, a noise reduction specialist, an insulation specialist or any of the many experts now available.

VE in Industry: Even Nuts and Bolts Are Challenged

All roads in value engineering lead back to General Electric Co. The concept was started there about 10 years ago under the direction of Lawrence D. Miles, who now heads the company's Value Service staff.

In addition to furthering the program at GE, Mr. Miles and his associates have trained value engineers for a number of military establishments. VE programs in the Navy, Army, and Air Force are based on techniques developed at GE.

The one objective of value engineering, as stated by Mr. Miles, "is to provide equivalent performance at lower cost." He and his associates now have a highly refined and effective method of operation to reach this objective. Put into print, it would provide a textbook covering all aspects of value engineering. Their initial approach, however, can be illustrated briefly. In analyzing any product or component, the value engineer begins by asking these questions:

- 1. What is the item?
- 2. What does it cost?
- 3. What does it do?
- 4. What else would do the job?
- 5. What would that alternative cost?

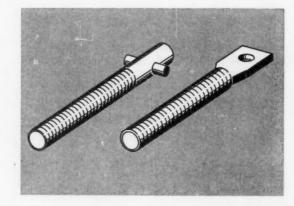
The answers to these questions can lead to the redesign of major subsystems as occurred in the LPD-1 program, or may be concerned profitably with the smallest components, as the following examples illustrate . . .

Example 1—Adjusting screw. Cost: 8 cents.

Function: To facilitate adjustment of electrical equipment. In use, a stiff wire was hooked into the hole in the head. The screw was lifted against a spring pressure, turned as desired, and then lowered again, allowing the cross pin to drop into a slot.

Manufacture of the screw required 3/16 in. and 1/16 in. diameter steel as raw material. The larger piece required cut off, threading, and drilling of two holes. The smaller piece required cut off, assembly in hole and staking.

The part was deemed so "unusual" that it was not to be expected that a vendor made such an item. A review of the function—not the part—brought



In the Future: SAVE

Whether or not value engineering is old enough and specialized enough to be of professional stature is debatable. One spokesman for the defense department, Mr. John J. Riordan, Office of the Assistant Secretary of Defense, describes the position of VE like that of quality control a decade ago.

"In the late '40s and early '50s, industrial management had heard so much of quality control that it became somewhat suspicious, if not disenchanted. Quality control had been sold as some kind of statistical gimmick. Because of its theoretical foundation in mathematics, it had an aura of mystery. It was something too potent for management to challenge, but also something too expensive for management.

agement to accept credulously."

The concept was finally defined and saved by scholarship. Publication of basic economic and technical literature on the subject (namely, the classical text by Dr. Walter A. Stewart) gave it a foundation which management could accept legitimately.

Many VE proponents would agree with Mr. Riordan that the precise stature of the concept is debatable—at the present. But they would also point out that the results achieved with value engineering are far from debatable.

Meanwhile, VE's most enthusiastic admirers are at work forming an organization called SAVE. The Society for the Advancement of Value Engineering aims to be a professional society.

forth these requirements:

- A screw having a hole in the top, or other suitable arrangement, so it can be lifted and turned.
- A head arrangement that will be pulled back into the slot and held so as not to turn.

A search of specialty products having these two characteristics uncovered the spade bolt, below. It accomplished all of the functions reliably and was readily available. Cost: 3 cents.

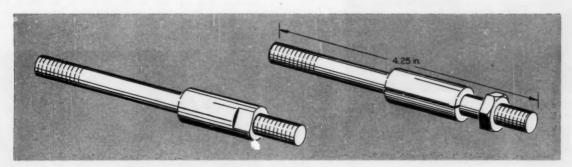
Example 2-Spacer stud. Cost: 15 cents.

Function: To hold an electric motor on a high-volume equipment, and space a dust cover over it. It offers no appearance or "esteem" values to the customer. It is a "use" part. Quantities are 400,000 per year. Material is steel; there are no close tolerances; the part is made on automatic equipment from standard steel rod; and there are no quality problems.

With the function clearly established as holding and spacing, comparisons were made to place the value on each function. The holding function can be compared in cost to that of a screw of similar dimension which would cost about $1\frac{1}{2}$ cents. The spacing function can be compared to a piece of tubing cut to proper length, or a piece of flat metal rolled to form a rolled spacer. In either case, the cost would be in the neighborhood of $\frac{1}{2}$ cent. Therefore, by comparison, the sum of the combined functions is evaluated at 2 cents.

Value engineers located a supplier of cold, upset, and roll-thread parts who proposed a suitable screw as shown at 1½ cents.

A supplier of rolled spacers, which were a specialty product for him, proposed a suitable cylindrical spacer at slightly under ½ cent. This spacer and the roll-thread screw assembled together ready for use would be an equivalent part costing 2 cents. Yearly reduction in cost: \$52,000.

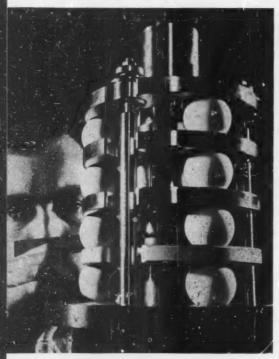


ACKNOWLEDGEMENT

This article is based principally on material submitted by Mr. Richard C. Johnson, Washington Technological Associates, Rockville, Md. Mr. Johnson was formerly assistant manager for the Shipbuilding Program and assistant for mechanical engineering and quality assurance in the Navy's Bureau of Ships, Information concerning the VE program at General Electric Co. is based on presentations at the recent Value Analysis Engineering Seminar conducted by the Army Ballistic Missile Agency, Redstone Arsenal.

PICTURE REPORT

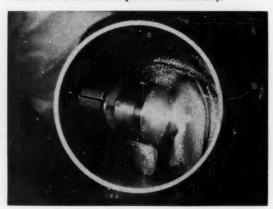
Dexterity for dangerous work is built into the Mark II Mobot, an electromechanical manipulating system developed by Hughes Aircraft Co. for environments unfit for humans. Each Mobot arm moves 180 degrees in any direction at shoulder, elbow, and wrist. The wrist will rotate continuously in either direction, and the hand telescopes $3\frac{1}{2}$ in. Television cameras and microphones at Mobot's wrists let the operator see and hear what the hands are doing. Motion commands, normally conveyed by switches, can be put on tape so that the Mobot can learn to perform complicated tasks after only one "lesson" from a human.



Space speeds exceeding 100,000 mph are promised by this foot-long ion engine introduced at the recent American Rocket Society meeting by Goodrich High Voltage Astronautics Inc. Porcelain spheres serve the two-fold purpose of insulating the engine and keeping its steel plates aligned.



Interior walls of small rocket nozzles, cylinders, and chambers can be sprayed with corrosion-resistant, high-temperature coatings with the new 25-kw arc-plasma gun made by Plasmadyne Corp., Santa Ana, Calif. The one-pound gun, which is less than 2 in. long and $1\frac{1}{2}$ in. in diameter, is claimed to be the smallest produced commercially.



MACHINE DESIGN



Space communication by sharply focused light waves may result from new continuous-wave optical masers developed by IBM scientists Peter P. Sorokin (left) and Mirek J. Stevenson. Operating on about 1/500 the power required by the ruby optical maser—the only previous coherent-light source disclosed—the new devices are based on ions of rare earth and transurance elements. Limitations of the ruby optical maser have restricted output to 1/1000-sec pulses at widely spaced intervals.

Exposure to gamma radiation can be avoided by heeding the audible and visible warnings of a pocketable instrument, the Personal Radiation Monitor. Pitch of the warning tone and flashing rate of the neon lamp increase with radiation intensity. Components of the instrument include a miniature Geiger counter, an electronic circuit using three transistors and five diodes, and a mercury battery. It was developed at Oak Ridge National Laboratory, operated by Union Carbide Corp. for the AEC.



A 95-ton payload can be carried by this tractor-trailer combination, which claims the distinction of being the largest production truck in the world. Built for the mining industry by K-W Dart Truck Co., Kansas City, Mo., the vehicle has a frame made of four heat-treated, pressedsteel channels, bolted together in pairs to form I-beams. Power is supplied by a four-cycle, 12-cylinder engine rated at 700 hp.





YOUR next house may have a gas heating system built into the baseboards. Prototypes for this and other new equipment are now in advanced stages of development at the American Gas Association's Cleveland laboratories. While these experimental units will eventually be shelved (AGA doesn't manufacture anything), many of the new design concepts will find their way into production equipment and into the home.

"In the next decade," says Walter B. Kirk, AGA's chief research engineer, "new ideas in residential appliances will be developed. Advanced knowledge on catalytic and pulsating combustion, and newly developed techniques (such as the

Vented to the outside, the experimental baseboard heating system also draws combustion air from outdoors. Single-port burner fires into a long tube. After combustion products reach the end of the tube, they reverse direction and travel back to the burner box. Blower, on the exhaust end, draws gases out of the heat exchanger.

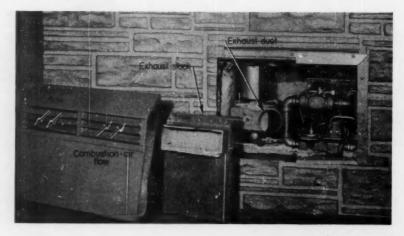
even burning of gas within long thin tubes) will influence the designer's approach." Other fundamental work, now going on, is showing how permissible heatrelease rates can be multiplied in combustion chambers.

Burner in the Wall

One of the most promising developmental projects at AGA in-

volves baseboard heating systems (picture, above). The approach is a new one: Burner and heat exchanger are located in an outside wall. Positioned horizontally, the prototype heat exchanger consists of an 8 ft long tube mounted inside an externally finned tube.

The burner fires into the small tube; combustion products travel to the far end, then back between the





with this

MASTER PLANNE

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Here's the long awaited answer to modern office planners, architects and efficiency engineers... the Master Planner scale model kit by Applied Research Corporation of Erie, Pa. With floor-space grid and these multi-combination 3 dimension scale components, office partition and equipment layouts can be made in a few minutes.

The Master Planner Kit contains a complete variety of parts that form limitless combinations of desks, bookcases, chairs, filing cabinets to meet all the requirements of office size and design . . . and to do it in a fraction of the time required to make drawings and prints.

Moreover, these quickly completed 3 dimension scale layouts can be photographed by office planners for discussion and decision at a great cost saving. No misunderstandings, no costly errors, no time wasted.

Furniture and partition kits are available separately or in combination. Molded parts are in two-tone complimentary shades of beige and brown. Each kit is furnished with a grid layout planning board and a corner wall section that adds realism to the layouts. The modern office comes alive quickly through the use of Applied Research Corporation's Master Planner.

The Master Planner is "modern magic" to prove the ancient Chinese Proverb that one picture is worth more than 10,000 words.

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two tubes. At the burner box, combustion air is entrained (from outside) and flue products are dis-

charged (outside).

The baseboard heater supplies heat by natural convection of room air around the finned tube. As presently operated (16,000 Btu per hr input to the 8-ft tube), air temperatures along the baseboard grille average about 210 F and temperature variation is less than 30 F. These temperatures could be reduced, but since the grill itself is insulated and cooled by room air, "it is not uncomfortable to touch," says Mr. Kirk.

Radiating the Kitchen

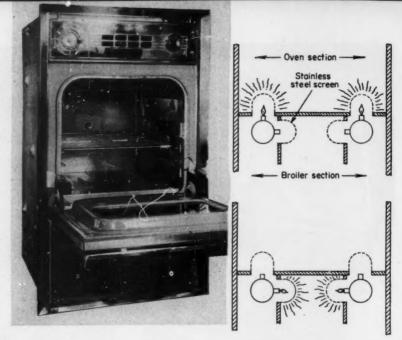
Future cooking equipment will rely heavily on radiant heat. Radiant burners in the kitchen range, pioneered by AGA, are already catching on with several equipment manufacturers, and radiant ovens seem sure to follow.

Oven-burner development is leading to some very radical designs that are proving out well in the laboratory. One of these is an experimental oven without sides, front, or back; i.e., with only a top and bottom. By locating one burner above the load (cake, roast, etc.) and one below, researchers have been able to bake with infrared heat alone—and they've cut down on baking time. This type of unit is not really practical, however, because quality of the bake has proved extremely susceptible to drafts.

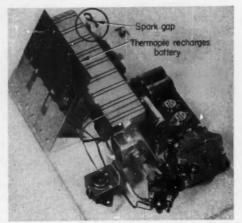
From this sideless oven, a more conventional prototype has evolved. In it, burners are mounted between oven and broiler sections. Rather than firing against the oven bottom. the burners heat up stainless-steel meshes. These meshes, radiating at a temperature between 700 and 1100 F (depending on the modulated input rate), heat the load while keeping oven wall and sides relatively cool. Advantages of this system include faster baking speeds, reduction of time required to preheat the oven, and decreased gas consumption.

Keeping Up on the Hardware

Residential equipment will require new "support hardware" as well as new burner and application



Burners fire vertically into stainless-steel meshes to bake by heat radiation (upper right). When the heat-control setting is changed from "bake" to "broil," a solenoid valve activates, directing gas flow to burner ports that fire sideways. These side-firing ports transfer radiation to the broiler (lower right).



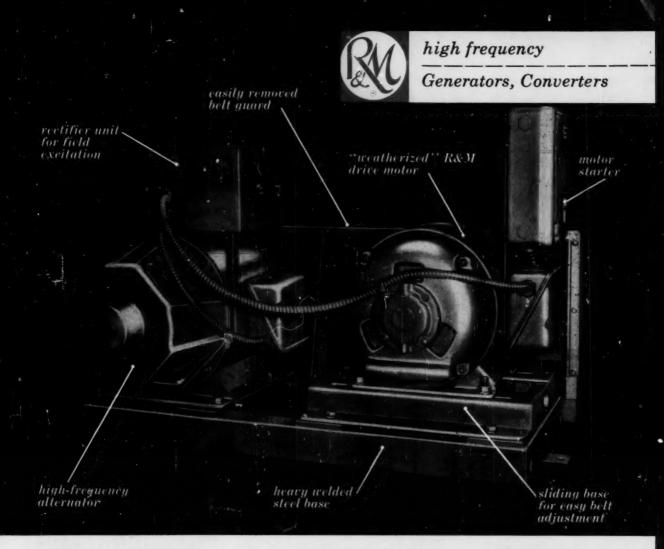
Spark ignition was developed to help cool kitchens (igniters don't consume energy when an appliance is off). Spark is generated for about 25 see while a capacitor is charging. When charged, the capacitor oppositely biases a transistor, switching the rechargeable battery (power source for the spark) out of the circuit. Gas supply, connected to the circuit through a solenoid valve, automatically shuts off if the burner doesn't ignite.

ideas. Many of these "extras" are also being researched at AGA:

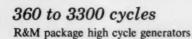
- Thermostats new designs for both snap-acting and modulating thermostats with negligible temperature overshoot are being developed and have already been incorporated in some equipment.
- Connectors heavy-duty flexible metal hoses, developed through a joint effort by AGA and Battelle Memorial Institute, are now being field tested. Work is also underway on design of quick-disconnect valves without "excessive" pressure-drop characteristics (a fundamental re-

quirement because gas supply lines operate at or near 7 in, water column pressure).

Next new hardware likely to show up on production appliances is transistorized spark ignition. Prototype systems that are applicable "across the board" operate from nickel-cadmium batteries. House current won't power the spark because heating systems, for example, must operate in case of power failure. Two types of rechargers are possible: A thermopile heated by the main burner, or a properly adapted trickle charger operated by house current.



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struction is used in ratings of 1500 cycles and lower. Ratings above 1500 cycles are brushless inductor design. Excitation of DC alternator field is provided by simple silicon rectifiers, protected against short circuits by timedelay fuses. For changing output frequency, R&M can furnish variable pitch pulleys or variable speed drives. R&M's low-cost frequency converters make 220 volt-3 phase-120 through 420 cycle power available from 6° cycle supply...rated 2½ KW (horizontal construction) 5, 7½ and 10KW (vertical).

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Sluggishness in computers is eliminated by

Ultrafast Thin-Film Memories

COMPUTERS with thin-film memories are finally on the market. Researchers at Remington Rand Div., Sperry Rand Corp., recently perfected a thin magnetic film, and the company lost no time in designing it into a "third-generation computer."

Meanwhile, another ultrafast memory is being readied for production. International Business Machine Corp. reports successful fabrication of a cryogenic thin-film memory plane and development of automatic techniques for duplicating the fabrication process.

Development of the magnetic-film memory "now makes possible a whole new generation of computers that operate in nanoseconds (billionths) instead of millionths of a second," declares Dause L. Bibby, Remington Rand president.

Consisting of a series of metal dots, the memory is only a few millionths of an inch thick. It's made by vapor depositing iron, nickel, or some other ferromagnetic materials on a glass plate (or other suitable substrate).

Easier to magnetize in one direction than in another, the new memory offers more than just switching-speed advantages:

- Thin-film memories are of the "catalogue type"—they can be questioned and read-out millions of times without being destroyed.
- Electric power needed to energize the thin films is less than with other memories.

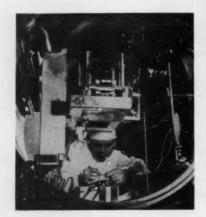


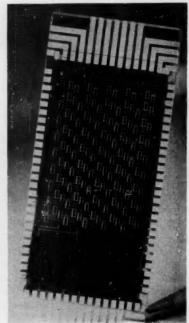


Computer response speed increases by 1000, claims Remington Rand, when the new thin-film magnetic memory (one substrate pictured above) is put to work. First computer to use the new memory is the Univac 1107, one of the fastest and most inexpensive superscale computers ever developed.

The IBM development marks the first time that scientists have been able to use automatic control techniques to duplicate cryogenic computer units. The memory plane, consisting of 135 cryotron devices built up in 19 microscopically thin layers, is postage-stamp sized.

Cryotrons are able to perform addition, multiplication, and other computer jobs because of their unique properties: As a magnetic field builds up past a critical value, the devices switch from a superconducting (zero resistance) to a resistive state. According to IBM spokesmen, the new automatically produced cryotrons will allow faster internal computer communication.





Nineteen layers of metal and insulator are sequentially deposited through 17 microscopically adjusted masks. In the new IBM technique for automatically fabricating cryogenic memories, the masks are changed like records in a juke box. Once they are properly aligned, the process automatically duplicates superconducting memory planes with similar electrical and mechanical characteristics. The finished sandwich consists of 135 cryotron devices.

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Circle 417 on Page 19

Meetings and Shows

Jan. 17-19-

Instrument Society of America. Winter Instrument - Automation Conference and Exhibit to be held at the Sheraton-Jefferson Hotel and Kiel Auditorium, St. Louis. Further information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Jan. 23-25-

Institute of the Aerospace Sciences. Annual Meeting to be held at the Hotel Astor, New York. Honors Night Dinner is Jan. 24. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Jan. 23-26-

Plant Maintenance and Engineering Show to be held at the International Amphitheatre and the Palmer House, Chicago. Further information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Jan. 29-Feb. 3-

American Institute of Electrical Engineers. Winter General Meeting to be held at the Hotel Statler. New York. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Feb. 1-3-

Second Winter Military Electronics Convention to be held at the Biltmore Hotel, Los Angeles, Sponsors are the National Professional Group on Military Electronics and the Institute of Radio Engineers, Los Angeles section. Additional information is available from IRE, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Feb. 7-9-

Society of the Plastics Industry Inc. Sixteenth Reinforced Plastics Div. Conserence to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from SPI headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 9-11-

National Society of Professional Engineers. Winter Meeting to be held at Hotel Fort Des Moines, Des Moines, Iowa. Further information can be obtained from NSPE headquarters, 2029 K. St. N.W., Washington 6, D. C.

Feb. 13-16-

American Society of Heating, Refrigerating and Air - Conditioning Engineers. National Meeting and 15th International Heating & Air-Conditioning Exposition to be held at the International Amphitheatre, Chicago. Additional information can be obtained from exposition headquarters, 480 Lexington Ave., New York 17, N. Y.

Feb. 26-March 1-

First Pacific Electronic Trade Show to be held in the Great Western Exhibit Center, Los Angeles. Additional information can be obtained from PETS headquarters, 2216 South Hill St., Los Angeles 7, Calif.

March 5-9-

American Society of Mechanical Engineers. Gas Turbine Power Conference and Exhibit to be held at the Shoreham Hotel, Washington, D. C. Co-sponsor is the U. S. Dept. of Defense. Further information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

March 6-8-

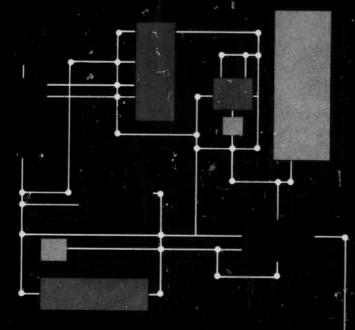
American Management Association. Data Processing Conference and Exhibit to be held at the Statler Hilton Hotel, New York. Additional information can be obtained from AMA headquarters, 1515 Broadway, New York 36, N. Y.

March 8-10-

Instrument Society of America. Annual Conference on Instrumentation for the Iron and Steel Industry to be held at the Roosevelt Hotel, Pittsburgh. Further information can be obtained from Richard R. Webster, Jones & Laughlin Steel Corp., Research Laboratory, 900 Agnew Ave., Pittsburgh 30, Pa.

March 11-14-

Steel Founders' Society of America. Annual Meeting to be held at (Please turn to Page 43)



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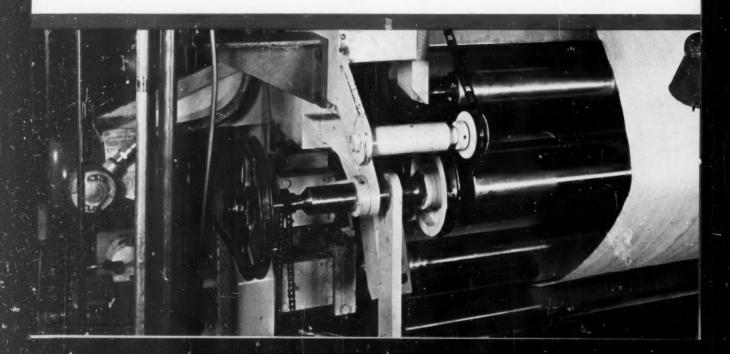
Constant improvement in products long recognized as "industry standards" is the story behind the selection of Vickers pumps for all the new American commercial jet airliners. Each Boeing 707, for example, uses two Vickers electrically depressurized variable pumps to operate landing gear, provide flight control boost and power compressors used in engine starting.

Numerous improvements in design, system reliability and contamination tolerance are the results of the latest phase of a continuing program that met the specialized needs of the new higher flying, faster commercial jets. These pumps are actually the fourth generation of a family that has fulfilled the hydraulic requirements of virtually every American-built transport in the last 20 years.

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Qualification tests far exceed the most rigorous service conditions.







MOBILE HY

New concept in powe

Maximum maneuverability with finger tip control is an outstanding feature of Caterpillar's new Traxcavator. The ease and precision of power steering means more than operator convenience—it pays off in more material moved every hour on the job.

A completely new concept in power steering, developed by Vickers research and engineering specialists, enables the Traxcavator to get this top performance in a system using *standard* components. Tailor-made power steering can be provided for vehicles with axle loadings from 1,500 to 128,000 lbs. by combining the right high pres-

PACESETTING HYDRAULICS like these...





MACHINERY

"Building block" pre-en

Maintaining constant tension on material during its 80-foot journey through this Inta-Roto plastic laminating machine requires precise synchronization of infeed rolls with the heavier combining rolls. A pre-engineered servo system based on the "building block" concept—made possible by Vickers research—meets these requirements perfectly, providing *instant*, *sensitive*, *accurate* response to changes in tension and speed.

In the "building block" concept Vickers offers standard hydraulic and electrical components pre-engineered into stem only from FACILITIES
LIKE THESE...



MOBILE HYDRAULICS DIVIS

New concept in power steering

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Complete system responsibi—insures high quality, matel Vehicle builders and users a vided responsibility for systemice. In addition, among facturers, only Vickers of interchangeability of parts.





MACHINERY HYDRAULICS DI

"Building block" pre-engineered ser

Maintaining constant tension on material during its 80-foot journey through this Inta-Roto plastic laminating machine requires precise synchronization of infeed rolls with the heavier combining rolls. A pre-engineered servo system based on the "building block" concept—made possible by Vickers research—meets these requirements perfectly, providing instant, sensitive, accurate response to changes in tension and speed.

In the "building block" concept Vickers offers standard hydraulic and electrical components pre-engineered into tested and proved systems tion in specialized engineeri controllable by any of th means currently available.

Custom designed systems, we required, can be developed complete line of Vickers ser components including: servo valves, motors, pumps, transducers and power supplies.

VISION

e, and the required cylinders . . . onent. All the elements are newly needs of today's more powerful

nsibility—offered only by Vickers matched components throughout. sers alike benefit from this undir system design, operation and nong hydraulic equipment manuses offers worldwide stocks and arts.



FOR FULL FACTS...

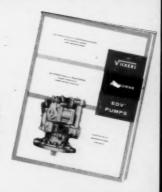
Concept of new, complete power steering systems is discussed in this 18-page brochure that describes basic installations and provides technical component information. Ask for Bulletin M5110.

Name	Title
Company	
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FOR FULL FACTS...

Features of electrically depressurized variable pumps and integrated controls are available in a pair of bulletins that include performance curves, weights, dimensions, etc. Ask for Bulletins A-6003.



Name	Title		
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DIVISION

ervo systems

ms—permitting a sizable reducneering costs. These systems are of the electronic programming ole.

ns, when ped from the s servo servo trans-lies.





FOR FULL FACTS...

Both electro-hydraulic servo components and pre-engineered "Building 'ock" systems are describe also bulletin. Operational in action on velocity and positional action of systems is included. Ask for Bulletin 60-70.

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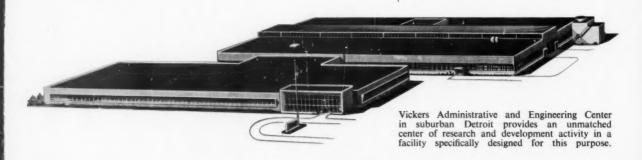
Spectrographic analysis is used to determine degree of impurities in semiconductor elements in research facility at Electric Products Division plant in St. Louis.

Industry's most comprehensive hydraulic research and development program

Dedication to research... the search for a new and better way... is the principle on which Vickers was founded and prospered. Today, that spirit continues in the form of intense research activities on a scale without parallel in the field of hydraulics and related sciences.

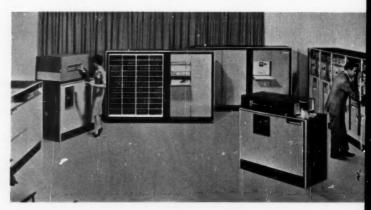
At all nine Vickers plants, research activities are carried on as a vital part of each day's business. The heart of Vickers research and development activity is carried on in the Administrative and Engineering Center. Here more than eight hundred engineers and technicians apply their skills in surroundings and with facilities designed expressly for this purpose only five years ago. Part of their effort is devoted to the constant improvement of products for the needs of today's customers in industry and defense, and a substantial part of the effort is devoted to creating the future in power transmission, energy conversion, and fluid transfer.

This dedication to constant improvement, to vision, to not accepting the existing simply because it does the job now . . . is your guarantee of products from Vickers which not only meet the need today but also contain a good measure of "tomorrow" as well.



Special test configurations simulate actual operating conditions. Here aircraft electronic cooling equipment is put through its paces.





Computers, both the analogue type and the solid state Univac digital type shown, are important tools in advanced planning of new products.



VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION

ADMINISTRATIVE AND ENGINEERING CENTER DETROIT 32, MICHIGAN, U. S. A. the Drake Hotel, Chicago. Further information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 12-16--

American Society of Mechanical Engineers. Aviation Conference to be held at the Statler Hilton Hotel, Los Angeles. Additional information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

March 13-15-

American Rocket Society. Flight Testing Conference to be held in Los Angeles. Further information is available from ARS headquarters, 500 Fifth Ave., New York 36, N. Y.

March 13-17-

National Association of Corrosion Engineers. Annual Conference to be held at the Statler Hotel, Buffalo. Additional information can be obtained from NACE headquarters, 1016 M & M Bldg., Houston 2, Tex.

March 13-17-

Society of Automotive Engineers Inc. National Automobile and Production Meetings to be held at the Sheraton-Cadillac Hotel, Detroit. Further information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

March 16-17-

American Society of Mechanical Engineers. Textile Engineering Conference to be held at Clemson College, Clemson, S. C. Additional information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

March 20-23-

Institute of Radio Engineers, International Convention to be held at the Coliseum and the Waldorf-Astoria Hotel, New York. Additional information is available from IRE, 1 E. 79th St., New York 21, N. Y.

March 20-24-

American Society for Metals. Thirteenth Western Metal Exposition & Congress to be held at the Pan Pacific Auditorium, Los Angeles. Additional information can ENGINEERING NEWS

be obtained from ASM, Metals Park,. Novelty, Ohio.

March 21-23-

American Power Conference to be held at the Sherman Hotel, Chicago. Sponsors are nine engineering societies, including American Society of Mechanical Engineers, National Association of Power Engineers, American Institute of Electrical Engineers, American Society of Civil Engineers, and American Society of Heating, Refrigeration, and Air Conditioning Engineers; Illinois Institute of Technology and 13 other universities. Additional information can be obtained from R. A. Budenholzer, Illinois Institute of Technology, 35 W. 33rd St., Chicago 16, Ill.

Short Courses and Symposia

Jan. 18-19-

Seminar on Machining and Forming Space-Age Metals to be held at the Statler-Hilton Hotel, Dallas. Sponsor is the American Society of Tool and Manufacturing Engineers, and further information can be obtained from the society, 10700 Puritan Ave., Detroit 38, Mich.

Jan. 23-Feb. 2-

Engineering and Management Course to be held at UCLA. Participants select four classes from a group of 22, including such subjects as reliability for modern industry, industrial psychology, engineering and research administration, and effective managerial communication. Public speaking classes are also offered. Further information can be obtained from Reno R. Cole, Co-ordinator, The Engineering and Management Course, College of Engineering, University of California, Los Angeles 24, Calif.

Feb. 14-16-

Second Annual Symposium on Nondestructive Testing of Aircraft and Missile Components (unclassified) to be held at the Gunter Hotel, San Antonio, Texas. Sponsors are the South Texas Section of the Society for Nondestructive Testing Inc. and Southwest Research Insti-



Whether it's supporting children on monkey bars or harnessing a spinning shaft you'll find NU-CUP set screws dig in deeper and hold tighter. The shaft illustrated here tells the story.

NU-CUP has a 42% sharper point which penetrates in a deep, full circle giving tremendous holding power. In some cases it actually reduces the number of set screws needed for the job.

You can get them in slabbed, slotted, hex or fluted socket.



SEND FOR FREE TEST SAMPLES and full information. Ask about NU-CUP set screws. Catalog 23 free on request.

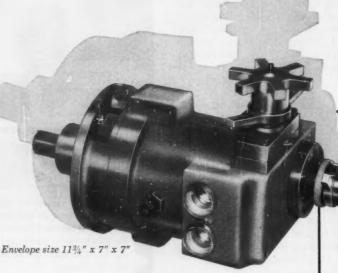


28 Main Street, Bartlett, Illinois

Circle 419 on Page 19

Light-weight, compact and extremely versatile - the reliable

IP 250 INDUSTR HYDRAULIC PUMP



by **LUCAS-ROTAX**

One of the complete new range of quality built hydraulic pumps and motors by Lucas-Rotax, the IP 250 offers many technical advances and advantages. • Small size • Low weight • Variable volume * Low noise level at higher operating speeds · Low cost · High efficiency · Fitted with integral or

remote pressure compensator as standard equipment. For further information, contact the agent or office nearest you today, or write for technical literature.

PUMP DETAIL

Basic Pump **Fixed Stroke**

Nominal Rating at 3,600 r.p.m... 18 G.P.M.

Displacement (cub. ins./rev.)... 1.157

Working pressure up to...... 5000 (lbs./sq. in.) (continuous).... 3000

4000

Speed up to..... (r.p.m.) (continuous)..... 3600

Input h.p. at 1,000 r.p.m. and

1,000 lb. per sq. in. differential 3.32

Weight..... 29 lbs.

Operating Temperature, ... °F - 40 to 200

Direction of Rotation..... Either

Pressure Compensator Range...500-5000

a product of creative engineering by

For further information con U.S. Representative: JULIUS KENDALL, Kenett Corporation, Kenett Corporation, 320 Washington Street Brookline 47, Mass. LOngwood 6-0378

OFFICES AND SERVICE DEPOTS THROUGHOUT NORTH AMERICA

BOSTON . NEW YORK . CHICAGO . LOS ANGELES . HOUSTON . SAN FRANCISCO . CLEVELAND JACKSONVILLE . DENVER . SEATTLE . BALTIMORE . TORONTO . MONTREAL . VANCOUVER



tute; further information is available from R. B. Wangler, Southwest Research Institute, P. O. Box 2296, San Antonio, Texas.

Feb. 22-23-

Seminar on Automation and Numerical Control, sponsored by the American Society of Tool and Manufacturing Engineers, to be held at the Bond Hotel, Hartford, Conn. Additional information is available from ASTME, 10700 Puritan Ave., Detroit 38, Mich.

March 20-31-

Industrial Packaging Short Course to be held at Purdue University. Additional information is available from Mark E. Ocker, Conference Co-ordinator, Div. of Adult Education, Memorial Center, Purdue University, Lafayette, Ind.

March 27-31-

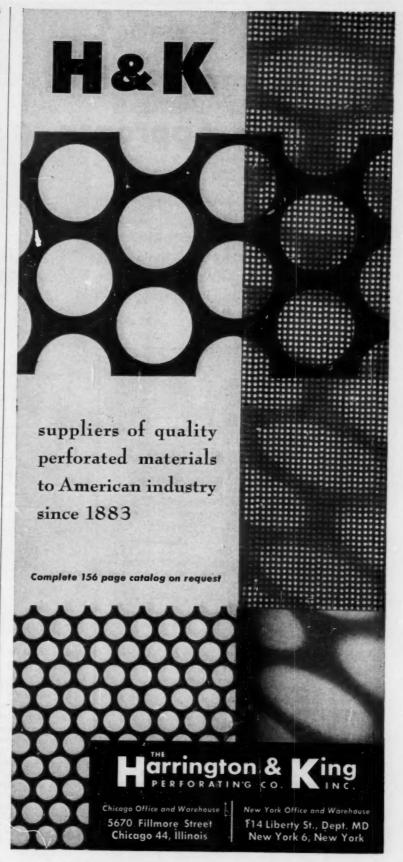
Third Symposium on Temperature—Its Measurement and Control in Science and Industry to be held at Veterans Memorial Auditorium, Columbus, Ohio. Sponsors are Instrument Society of America, American Institute of Physics, and National Bureau of Standards. Further information is available from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

March 28-

17th Annual Quality Control Clinic to be held at the University of Rochester, Rochester, N. Y. Sponsor is the Rochester Society for Quality Control. Further information can be obtained from Albert D. Rickmers, Associate Professor, College of Graphic Arts and Photography, School of Photography, Rochester Institute of Technology, 65 Plymouth Ave. South, Rochester 8, N. Y.

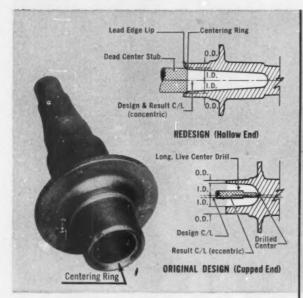
March 28-29-

Symposium on Nucleonics in Flight to be held at the Statler-Hilton Hotel, Dallas, Texas. Symposium will consider nuclear aspects of atmospheric and space systems for manned and/or unmanned space travel. Further information is available from Eldred L. Burkhard, Chairman, North Texas Section, American Nuclear Society, Convair Div., Forth Worth, Texas.



How to Improve Parts Design with This Fresh Approach to Forging

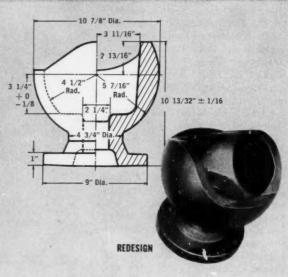
Many parts in use today are better as a result of design refinements suggested by COMMERCIAL's forging experts. Below are examples of COMMERCIAL upset forgings which demonstrate how these design refinements have resulted in superior parts for the OEM at lowered cost. These examples may appear to you as unusual in design—and this is the point...



Forging Redesign . . . Cuts Cost, Eliminates Tool Breakage, Cuts Scrap

Original design of axle spindle forging required chucking on the O. D. to enable center drilling of both ends. Part was held between drilled centers for overall machining. Concentric cupped axle end was center drilled blind with long, live center drill. O.D. and I.D. concentricity was difficult to maintain—causing eccentric drill centers. Result: tool breakage and machining scrap.

COMMERCIAL's redesign calls for a centering ring on inside edge of hollow end, forged without concentricity problem. Lead edge lip protects this important centering ring. The part can now be held for overall machining by a dead center stub engaged in the centering ring. Result: center drilling of open end not required, tool breakage eliminated, no machining rejects, metal savings.



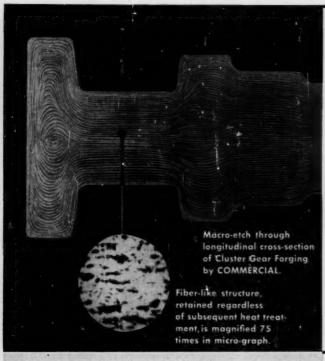
Unusual 80 lb. Forging . . . Reduces Cost, Replaces 95 lb. Casting

Ball joint housing for heavy duty steer and drive mechanism... formerly a steel casting. Field failures were traced to hidden metal faults. The housing was unable to withstand shock loadings encountered.

Problem: redesign for required strength-part to be no larger, no heavier, same shape.

Solution: an upset forging of unusual shape—flanged on one end, belled on the other, open at both ends. Commercial collaborated in the design and produced the part free of hidden metal flaws with sound, tough metal throughout—failures eliminated. Plus... weight saving over 15%, saving in machining cost 10%, greater strength-to-weight ratio.

When it's a vital part,

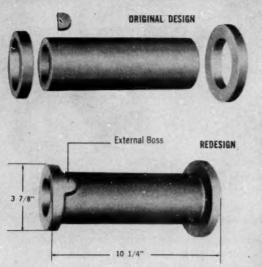


Metal Quality Facts

Forgings start with "Forging Quality" rolled steel . . . steel that is closely controlled in its making for the purpose of eliminating defects and obtaining soundness-surface and interior. Such quality steels have been hot worked to obtain maximum development of their potential physical properties. Grain structure has been refined into a fibrous flow in the direction of working.

Mechanical hot forging of "Forging Quality" steel forces the metal in its plastic state to conform to specified shapes and achieves a vast improvement in its "as rolled" metal quality. Forging kneads the metal into a dense mass of strength and toughness and positions it into commercially exact dimensions and shape in all directions.

Upset Forging in closed dies produces by squeeze pressure a "looped" grain flow and permits concentration of grain density at points where the service stresses are calculated to be the greatest. Also, control of the directioning of the inherent fiber-like structure provides for maximum strength of the metal at required stress points. Not only are the properties of the metal improved in all directions but also the metal structure is refined and compressed resulting in a structural uniformity that renders the metal remarkably free from concealed defects.



One Piece Forging . . . Lowers Cost, **Eliminates Four Piece Weldment**

Blank for hydraulic cylinder outer barrel used to position Nike missile...originally a weldment—a tube, two flanges and a boss.

Problem: cut unit production time to meet crash program schedule, reduce assembly and machining cycle, increase strength-to-weight ratio.

Solution: a difficult upset forging because of external boss, COMMERCIAL tooled and produced the part in one piece to print. Assembly time eliminated, less distortion...improved machining conditions, forged to closer tolerances, uniform metal quality, added tensile and torsional strength due to controlled grain flow, strength p-weight ratio increased, delivery schedule satisfied.

design it to be FOREED



Advantages of Upset Forgings

- Uniform strength, toughness and high fatigue resistance insure longer, more dependable service life for equipment.
- Parts made closer to finished dimensions-cuts scrap, reduces machining and finishing time.
- Components can be assembled by simple production methods into complex parts.
- Uniform response to heat treatment gives desired physical properties of precise degree.
- Higher strength-to-weight ratio obtainable-a vital factor in the design complexity of parts for the future.

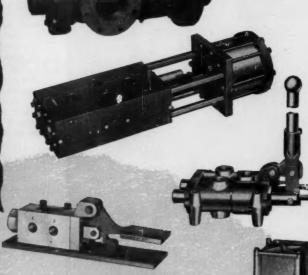
Features of Upset Forging by COMMERCIAL

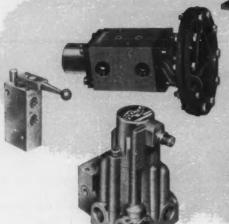
- Batteries of upsetters from 11/2" to 8"-custom or production runs.
- Hydra-Jet descaling prior to forging reduces imbedded surface scale.
- Magnetic particle depth inspection to detect metal faults before shipment.
- "Task Forging" team steeped with experience in producing the unusual upset forging.

While designs are on the board, call on COMMERCIAL'S "Task Forging" team to collaborate with you-send print or sketch, sample or prototype. Address: Commercial Shearing & Stamping Co., Dept. S-1, Youngstown 1, Ohio.

COMMERCIAL shearing & stamping









For more information, write for Bulletin 603. Address Dept. MD-161, Hunt Valve Company, Salem, Ohio. Whatever the application . . . whatever the service . . . whatever the pressure range . . . whatever the size . . . whatever the actuation required . . . chances are you'll find a valve in the Hunt line exactly suited to your needs.

Sizes range from 1/8 through 8 in. for vacuum to 300 psi air and for water, soluble oil and water, or oil to 5000 psi.

Your nearby Hunt representative will be pleased to work with you. You'll find him listed in Sweet's Product Design File.

HUNT

QUICK-AS-WINK® AIR AND HYDRAULIC

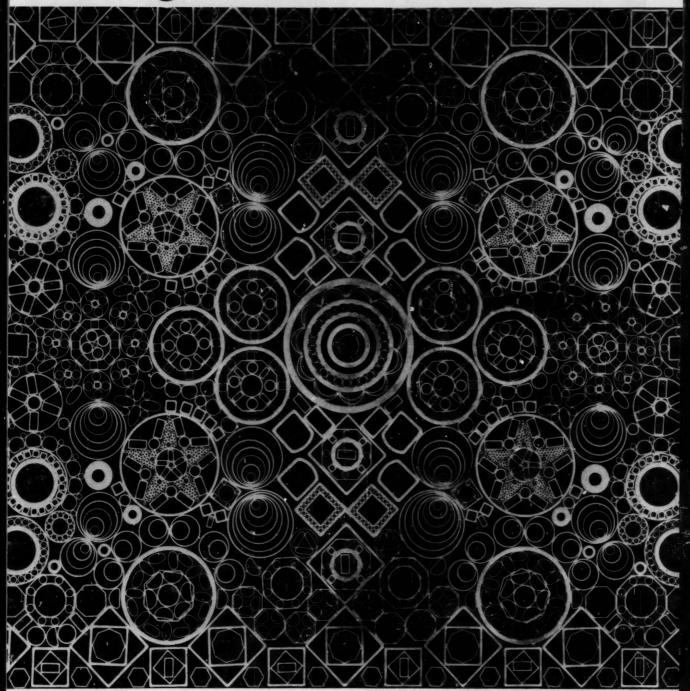
VALVES

HUNT VALVE COMPANY . DIVISION OF IBEC . SALEM, OHIO

3001



This mark tells you a product is made of modern, dependable Steel.



Seamless Steel Tubing comes in almost every shape and size, that is, if it's USS National Seamless Mechanical Tubing.

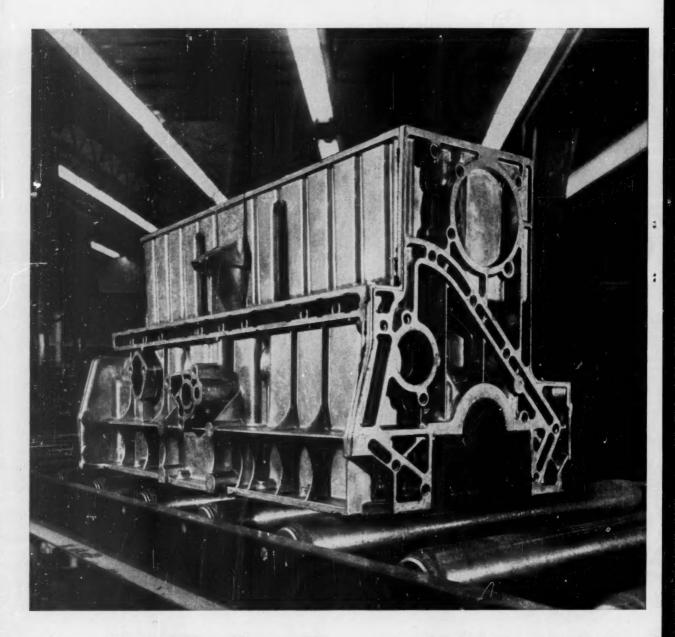
USS and National are registered trademarks



National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors; United States Steel Supply Division; United States Steel Export Company, New York

Circle 425 on Page 19



World's first die-cast aluminum "six"

Saves 80 pounds for American Motors' new Rambler Classic . . . incorporates specially bonded cast iron liners in dry sleeve design.

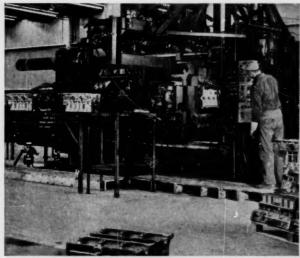
This engine block is the biggest die casting ever mass produced. It's the world's first six-cylinder block for passenger car use to be die cast in aluminum.

It's a 67 pound lightweight including 14 pounds of centrifugally cast iron cylinder liners. That means a total saving of 80 pounds deadweight...now standard in the new Rambler customs, optional in other Rambler models.

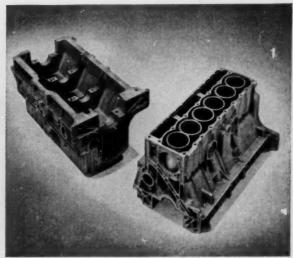
Light but strong. Aluminum's excellent physical proper-

ties are fully utilized by careful die cast design and photostress analysis. Outstanding strength, soundness and precision provide a big plus for heavily-emphasized Rambler quality.

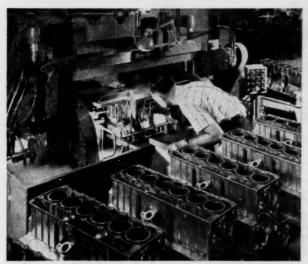
BMI bonding is simple and sure. The BMI—or Bi-Metallic Interlock developed by Doehler-Jarvis—mechanically "anchors" the liners by means of their specially prepared cast surfaces. Since these liners are centrifugal castings, no knurling, crimping or splining is needed. An intimate locking action occurs as the molten aluminum is injected into the die . . . under 8,000 psi. The result: an inseparable bond with excellent heat-transfer properties.



A block every three minutes . . . from 2,000 ton machines like this. In three tenths of a second, machine injects a 70-pound "shot" of molten aluminum . . . under 8,000 psi.



Centrifugally cast iron liners—up to 260 Brinell—are cast in place with specially prepared surfaces which lock inseparably with molten metal under pressure.



Pressure tightness of die-cast aluminum blocks is determined by testing on a machine specifically designed for this purpose. Advanced quality control helps protect highest standards.



Palletized for rapid delivery, these finished blocks can reach American Motors assembly plants by rail . . . or in trucks of the Doehler-Jarvis fleet.

rolls off the line at Doehler-Jarvis

To design for efficient production, American Motors and Doehler-Jarvis engineers combined specialized know-how with liberal imagination. An oil gallery for hydraulic valve lifters is an integral part of the block casting. Liner inserts and loose pieces for casting undercuts are placed by automatic attachments that never slow down the casting cycle.

To make new ideas pay off, perhaps you can use the facilities, resources and practical experience offered by Doehler-Jarvis. Eight plants provide the capacity—and the flexibility—to serve large companies well, and to help small ones grow. For detailed information, simply phone or write the nearest Doehler-Jarvis plant or office.

Doehler-Jarvis

Division of
NATIONAL LEAD COMPANY
General Offices: Toledo 1, Ohio

Q 6.

Plants at: Toledo Grand Rapids 2, Mich. Pottstown, Pa. Batavia, N. Y.

Co. Limited

In Canada: Barber Die Casting Co. Limited
Hamilton, Ontario

In Brazil: Industrias Doehler do Brasil, S. A.
Sao Bernardo do Campo, Sao Paulo



TUTHILL PUMPS Lubricate GARDNER-DENVER'S RP-900 Compressor

Gardner-Denver describes its new model RP-900 as "the finest rotary compressors on the market". Developed for operation under the most extreme climatic conditions the new units are designed to provide the greatest possible dependability in the roughest service.

Essential to the RP-900's dependable performance is its lubricating oil pump. Gardner-Denver selected Tuthill to work with its engineers in developing a unit which would provide positive and metered oil-flow to assure lubrication, cooling and sealing under all operating conditions.

Tuthill's standard pump 5C, especially modified to meet the demands of this particular application, was selected. Adapted for operation at 1800 rpm, the Tuthill unit is mounted directly on the compressor rotor shaft. Special mounting brackets and shafts, developed by Tuthill's engineers, facilitate assembly and maintenance of the compressor.

Tuthill manufactures a complete line of positive displacement rotary pumps with capacities from 1/2 to 200 gpm; for pressures to 1500 psi; speeds to 3600 rpm.



The model 5C, modified for use by Gardner-Denver, is only one of over 800 standard models in Tuthill's complete line... providing a complete selection for a wide variety of requirements in lubrication, hydraulic, coolant, refrigeration, air conditioning, and many other services.

Very probably a Tuthill model will supply an economical, dependable answer to your pumping problem. For special applications, Tuthill's engineers have extensive experience in modifying these standard units, as for Gardner-Denver above. Or they will work with you in developing an entirely new unit, adapted in every detail to the requirements of your application.

Catalog 100 gives an over-all picture of Tuthill's complete line. Write for your copy today. Or, to speed things up, send drawings or other information on your application so that our engineers can indicate ways in which Tuthill's pump know-how can save you money.





We address this statement to design, tool, production, inspection and assembly engineers...

Holding to extremely close tolerances is a costly procedure. You know that, What you may not know is that frequently you can ease up on tolerances without sacrificing a single thousandth of your precise assembly objectives.

How? By using LAMINUM!

LAMINUM is the registered trade name for laminated shims whose layers are completely surface-bonded to look and act like solid metal. The layers are easily p-e-e-l-e-d to bring the shims to any desired thickness—for a thousandth fit right at assembly.

With LAMINUM in the specs, machining operations become less critical, faster and less costly. Inspection is simpler and less costly. The savings carry over to the assembly line, too. No stand-by equipment. No machining. No grinding. No counting, stacking or miking. And no dirt between layers—ever!

Get the facts about costsaving LAMINUM, and the custom-stamping service that goes with it. They're all illustrated and described in our Shim Design Folder No. 4. Write for it.



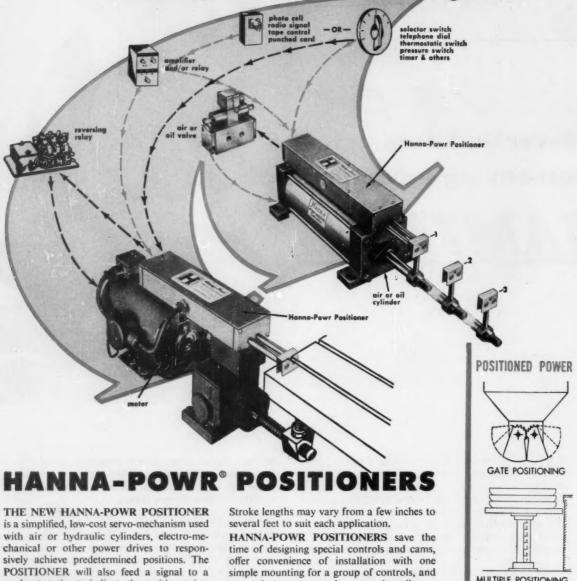
THE LAMINATED SHIM COMPANY, INC.

West Coast Sales and Service 600 SIXTEENTH ST., OAKLAND, CALIF.

Home Office and Plant
1201 UNION STREET, GLENBROOK, CONN.

Circle 429 on Page 19

BRAND NEW IDEA... multiple positioning in a simple, low cost package!



read-out station to indicate the position point. Controls, such as selector switches, timers, thermostatic switches and others, feed signals to the POSITIONER for station selectionas many as 14 per foot of stroke. Infinite variations in positions are possible by simple movement of the adjustable limit switches.

cut maintenance costs by protecting all controls in a sturdy, dust-tight housing.

Your individual problems will suggest many uses for the HANNA-POWR POSITIONER. For more detailed information call your nearby Hanna Representative, (See "Cylinders" in the yellow pages), or write us for Catalog 500.



60 Years' Experience In Suilding The Finest Cylinders, Valves and Other Hydraulic and Pneumatic Equipment



Engineering

1751 Elston Avenue * Chicago 22, Illinois * BRunswick 8-2710



Atoms clobber a \$20-million-a-year pest

How Nickel Stainless Steel helped fight costly cattle menace

A few small flies can kill a full-grown steer in ten days.

They call this killer Callitroga hominivorax, or screwworm fly. It used to cost Southeast cattlemen 20 million dollars a year.

Thanks to a peaceful use of atomic energy, the U.S. Department of Agriculture reports that Callitroga hominivorax was completely eradicated within seventeen months. This achievement may mark a new precedent in modern methods of pest elimination. Over two billion laboratory-raised male flies were sterilized by atomic radiation and then released. Because the females then laid sterile eggs, the screwworm fly population was destroyed.

Sterilization was accomplished by exposing males to gamma radiation from Cobalt 60 within a lead-shielded cask of Nickel Stainless Steel.

Nickel Stainless Steel was chosen by the designers, Knapp Mills Inc., for several reasons. It gives strength and rigidity to the cask's interior for greater handling safety. It stands up to the nitric acid solution used for radioactive decontamination—a cleaning process that plays havoc with less corrosion-resisting metals. And its sanitary, attractive appearance adds sales appeal to any product.

Are you in the atomic energy field ... or any field where you need a metal with a combination of superior properties? Consider the advantages of Nickel or one of its alloys when planning the construction of your equipment. Help with any metals problem is available from Inco. Just call or write us.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street Mew York 5, N.Y.

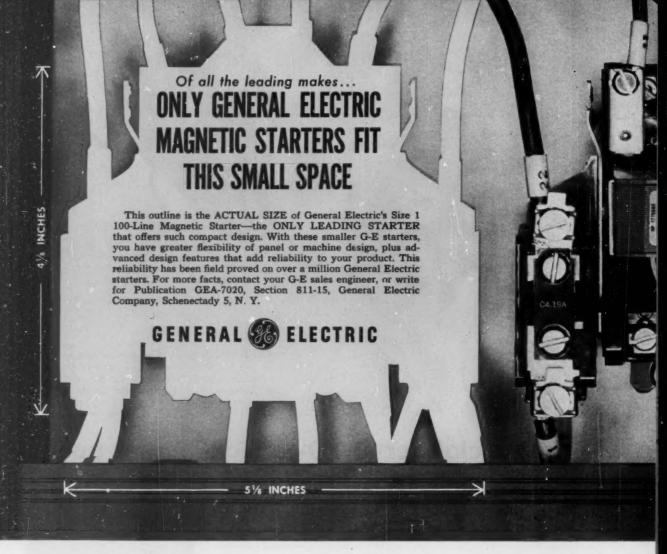


The Irradiator, nemesis of screwworm flies, is fabricated of Nicrolum*—a Nickel Stainless Steel to which lead has been metallurgically bonded. Six of these machines brought the fly menace under control.

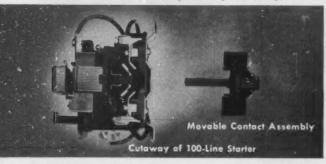
*T.M. of the designer-manufacturer, Knapp Mills, Inc., Long Island City, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER



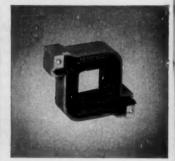
Add reliability to your product by using 100-Line starters



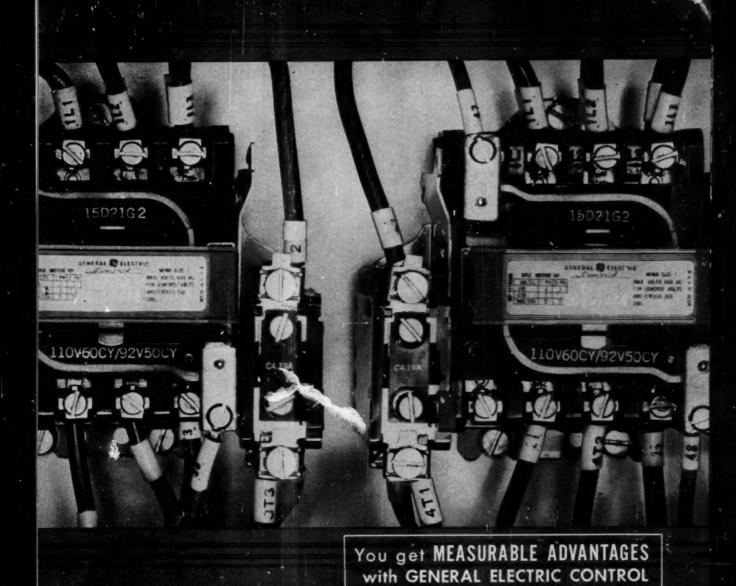
LESS BOUNCE, LONGER LIFE RESULT FROM SLANTED CONTACT DESIGN, MORIZONTAL ACTION. Bounce on closing and dust accumulation are two major causes of contact deterioration. General Electric's slanted contacts and horizontal action virtually eliminate both problems. The unique angled mating of contact surfaces provides positive "make" and "break," with less bounce, less resultant arcing. The slanted surfaces shrug off dust and other contaminates that could cause contact pitting.



MAGNETIC STEEL ARC TRAP EXHAUSTS CONDUCTIVE GASES, REDUCES CONTACT EROSION. Size 2 starters feature arc trap which exhausts ionized gases, contains and quenches arcs. Arc trap splits and cools arcs quickly, reducing contact erosion, extending contact life.



STRONGBOX MOLDED COLL PROVIDES POSITIVE PROTEC-TION FOR COIL WINDINGS. Glass-filled alkyd resin protects coil to prevent flexing of windings, and resists dirt, oil, water, and mechanical damage.



Only General Electric gives you all these proved features



POSITIVE "MAKE," CLEAN DROP-OUT PROVIDED BY G-E MAGNET DESIGN. Any voltage sufficient to move magnet seats it firmly. Clean drop-out results from machined air-gap, short flux path.



STRAIGHT THROUGH WIRING ALLOWS QUICK, NEAT INSTALLATION. All line terminals are at top, all load terminals at bottom. This speeds installation, provides neater appearance. Pressure type terminals accept solid or stranded wire, ring or spade connectors.



BIMETALLIC OVERLOAD RELAYS ARE TRIP-FREE, ADJUSTABLE ±15%. Bimetallic relays standard on 100-Line starters, cannot be reset while overload exists. Handy knob allows ±15% adjustment of trip setting. Overloads can be reset manually or automatically.



FULL-FRONT ACCESSIBILITY ALLOWS EASIER INSPEC-TION, WIRING, MODIFI-CATION. No extra space needed—contact inspection, coil change, averload adjustment done from front.





Energy Cartridge













Die





Discs

















springs

Answer your "where to get it" questions-

by calling on the versatile experience represented by these typical springs and stamped parts. Here is unusual ability to analyze your part from both design and production efficiency and to make cost-saving contributions where possible. Whether your requirements are large or small, routine or extreme precision, you'll get a better brand of service and quality from the best springmakers in the business.

> Send for "Pocket Guide to Springs and Other Things" -a quick picture of our products and services.

and other things

custom-made to quality standards















Clips











Wire Forms

Associated Spring Corporation

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y. Raymond Manufacturing Division, Corry, Penna. F. N. Manross and Sons Division, Bristol, Conn. **Dunbar Brothers Division, Bristol, Conn.**

Wallace Barnes Steel Division, Bristol, Conn.

Ohio Division, Dayton, Ohio Cleveland Sales Office, Cleveland, Ohio Chicago Sales Office, Chicago 46, III.

B-G-R Division, Plymouth and Ann Arbor, Mich. Gibson Division, Mattoon, III. Milwaukee Division, Milwaukee, Wis. Seaboard Pacific Division, Gardena, Calif. Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

General Offices: Bristol, Connecticut



T. R. Corn, Sales Engineer, Akron District Office.

RELIANCE ELECTRIC AND ENGINEERING COMPANY



Reliance meets the peculiar needs of progress.

Loading or unloading of United Jet Mainliner passengers in three minutes is now an accomplished fact at major air terminals.

Product of the jet age, this "Jetway" passenger loader came to life as a result of some unique engineering on the part of Reliance and the Pacific Iron and Steel Co.

Reliance engineered a drive system that makes the "Jetway" as easy to handle as an automobile. One operator moves it into position against the plane doors in less than a minute. Operation is smooth and stepless. Separate controls compensate for weight changes as the load shifts from plane to ramp and vice versa.

Adapting Reliance products to this unusual vehicle called for imagination and ingenuity . . . and the "Jetway" works fine.

The "Jetway" ramp now is used by several major airlines, and is operated by Reliance gearmotors, electronic exciters and motor-generator sets which convert airport a-c. power to d-c. More "Jetway" ramps are being installed at important terminals throughout the country.

RELIANCE ELECTRIC AND ENGINEERING COMPANY



Something more than electricity keeps this Reliance Motor running.

The oil field motor that drives this unit is protected, inside and out. It is not affected by dust, dirt, water or changes in the weather.

Reliance engineered and built this weather-proof motor, which is operating an oil well pump, in order to provide continuous operation with negligible maintenance . . . otherwise it wouldn't be where it is.

There are many such areas in the country where Duty Master Motors are subject to extreme environmental conditions. Yet the weather-proof is only one of a broad line developed to meet any a-c. motor requirement . . . and that takes in a lot of territory. Duty Master's wide acceptance is testimony to the creative engineering which produced it.

This 15 hp. Duty Master operates an oil well pumping unit at the Fair-Glenn Field, Sapulpa, Oklahoma. Sound insulation, rodent screens and the "Metermatic" lubrication system are vital qualities of this motor which performs so well in areas where weather and infrequent supervision are factors. It runs 24 hours a day regardless of adverse conditions.

RELIANCE ELECTRIC AND ENGINEERING COMPANY



It takes more than horsepower to make a quality product.

These two super-calendar machines put a rich, glossy finish on paper. Alternate steel and cotton rolls produce a buffing, or polishing action on the previously treated product. Reliance Drives keep speeds of various rolls exactly regulated so that uniform, precise tension is maintained.

The big design trick here is to maintain exact tension during acceleration and deceleration of the drive system. Process requirements call for frequent speed changes. Any variation of tension during these changes is dangerous. The paper "web" can break, rolls can jam, the system can go haywire. But this one doesn't.

Reliance Engineers were in on this installation from start to finish \dots worked with company engineers to assure sound operation.

Tachometer feed-back systems with Reliance regulators keep the system perfectly controlled. Motors are synchronized to keep paper flowing smoothly at 2,000 feet per minute. A total of six machines in this mill are powered and controlled by Reliance, testimony to creative engineering and intelligent application.

Reliance Sales Engineers are ready to help your company solve motor and drive application problems . . . and they will act quickly and efficiently. There is a Reliance office near you. Check your telephone Yellow Pages . . . write, or call us direct.

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 344A, CLEVELAND 17, OHIO Canadian Division: Toronto, Ontario Sales Offices and Distributors in Principal Cities



Some Ideas



for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO ...

Six years ago, K&E introduced the very first polyester-base drafting film-a specialpurpose medium featuring extreme dimensional stability. Experience with that film indicated that a definite need also existed for a general-purpose drafting film, if one could be perfected. About two and a half years ago we succeeded, introducing HERCULENE® Drafting Film-the first polyester-base medium for general drafting to meet professional standards. Many recognized its value immediately, stocked up on HERCULENE, and have used it happily ever since. Others - a bit more "canny" about adopting a relatively untried medium - deferred decision, saying "see us in a year or so." Still others having tried one or more of the other films marketed immediately after HERCULENE seemed permanently disenchanted with all film based media. What with the passage of time and much favorable ado about drafting films in general, we rather think that those once stung may now have adopted a more congenial attitude - so we address ourselves solely:

To fence-sitters everywhere . . .

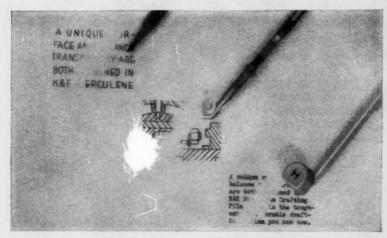
Just as we felt in '58, we feel today, that film has an important place in the drafting room. The only difference now is that experience has proved it so. Since 1958, the number of HERCULENE users has grown by leaps and bounds. All, we're happy to say, have found HERCULENE a welcome, efficient, and much needed addition to their stock of drafting media. It is these HERCULENE users who have written the record. Their many and rigorous tests, their months of experience, their numerous successes and continuing satisfaction are convincing evidence that HERCULENE is all we said it would be.

Why all the fuss about HERCULENE?...

HERCULENE combines practically all the qualities of a perfect drafting medium. An excellent product when introduced, it's even closer to perfection today. Working with major film users. K&E specialists have refined HERCULENE in many subtle ways since its introduction.

Unlike cloth or paper, HERCULENE is virtually indestructible. No matter how roughly or frequently a HERCULENE tracing is handled, it will never crack, wrinkle or fade. Absolutely waterproof, a HERCULENE drawing can never be permeated and ruined by moisture. Filed away, HERCULENE will last indefinitely. And HERCULENE has body, too, making it far easier to handle and file, and to keep flat on the drawing board.

Most of the refinements made in HERCU-LENE since 1958 have concerned its engi-



neered drafting surface. HERCULENE's surface "take" for pencil, ink and typing is now better than ever. Erasability, of course, is excellent for all three. Contrast has been built up for sharper definition of line, too, yet all the transparency necessary for fast, clear reproductions has been maintained.

Two big bonuses, too . .

A significant chapter in the HERCULENE story has been the development of a water-proof writing mate — the Duralar plastic pencil. Drawings made on HERCULENE with this waterproof pencil can actually be



washed in soap and water. Even gray, grimy "unreproducible" drawings can be washed spotless with this new technique. Many firms now use the HERCULENE/

Duralar team exclusively . . . and are realizing undreamt-of savings in costly re-draws. Some firms, of course, by virtue of smaller work volumes and "cleaner" or less frequent handling, will have little need for this new wash technique. Of particular interest here is another K&E exclusive recently introduced - the amazing Ruwe pencil. The Ruwe pencil will not withstand washing, but in every other respect, this new pencil is graphite-plus. Although of plastic composition, the Ruwe pencil has all the "fine" feel of graphite, erases well. and deposits a sharp, dense black line. The big bonus: Ruwe pencil lines are virtually smudge-proof. Rendered on HERCULENE's engineered drafting surface, they actually resist smudging better than graphite on regular paper!

We leave it to you...

The best test remains the one you make for yourself. We've just completed a new brochure, titled "A Report on the Growing Acceptance of Polyester Film." In it is detailed most of what we have learned about HERCULENE and its use since 1958 — including tests you can make to assess its every property. We'd like you to have a copy of this new brochure — plus a sample sheet of HERCULENE, a Duralar pencil, and a Ruwe pencil — for your own private testing. To get these free samples, simply fill out and mail the coupon below:

KEUFFEL	& ESSER	CO., Dept. MD-1.	Hoboken N J	

Gentlemen:

Please send me your new brochure, titled "A Report on the Growing Acceptance of Polyester Film," a sample sheet of HERCULENE Drafting Film, and samples of the Ruwe and Duralar Pencils.

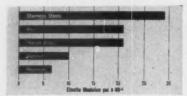
Name & Title

Company & Address _

How to improve product design through better material selection

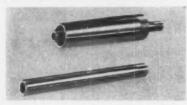
This advertisement is one of a series on the advantages of Carpenter Stainless Steel. As a handy reference for material selection, these data can pave the way for successful results on your next assignment.

Higher elastic modulus



The elastic modulus of an alloy is one of the most important properties used in the design of springs, fasteners, diaphragms and many other components subject to stress in service. Materials with a high modulus deform very little under load; materials with a low modulus may be completely unsatisfactory because of excessive dimensional change. Stainless steels with a modulus of about 29 million psi., are ideal for use in such structural components particularly when either corrosion or heat resistance is also needed. The chart above shows the elastic modulus of materials sometimes considered for such applications.

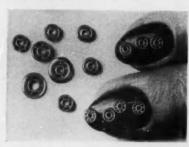
Better corrosion resistance



A good example of Carpenter Stainless resistance to corrosion. The nozzles used to fill storage batteries with electrolyte were formerly made from hard rubber. These rubber nozzles did not corrode, but they broke frequently, and proved costly to replace. After switching to Carpenter Stainless No. 20Cb, all problems were solved. No breakage . . . no corrosion . . . more

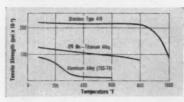
production per shift. The perfect choice of material for this highly corrosive application.

Increased productivity



Big results in miniature . . . with Carpenter Mel-Trol® Stainless No. 440-C. Ten of these miniature precision bearings laid side by side measure only one inch in length! A miracle in close tolerance machining was required to fabricate the race and ball retainers for these bearings. Since a change to Carpenter Mel-Trol No. 440-C, this manufacturer has realized a 200% increase in production. A big improvement for a small item.

Elevated temperature properties



Much of the newer industrial and military equipment is being designed for service at temperatures higher than ambient but not high enough to justify the use of the special high temperature alloys, for example, the maximum operating temperatures of 400 to 800°F. Alloys other than stainless steels have been considered for such applications but from both an economic standpoint and the stress requirements, one of the stainless steels is usually found to be the best selection as indicated in the chart above.

Application engineering service

To help improve stainless steel performance on almost every application, Carpenter has placed in the field this extra service for all its customers. Armed with skill and technical knowhow, each Carpenter Representative is available for ideas and suggestions to improve the products you are contemplating. His vast knowledge of new products, plus application guidance and practical assistance can be of great help to you. Get in touch with the Carpenter Representative nearest you. You'll find him a good man to have on your team.



Additional help

Space does not permit a complete listing of description and application suggestions for all grades of Carpenter Stainless Steels. For detailed information on all grades of Carpenter Stainless, write today for the Technical Data Sheets available upon request.

Are you getting all these performance characteristics in the materials you specify?

- ☐ brilliant finish ☐ maximum strength
- corrosion resistance
- ☐ uniformity ☐ hardness
- versatility
- ☐ good machinability
 ☐ ease of fabrication
 ☐ exacting tolerances
- long service life customer satisfaction
- Carpenter Stainless gives you all these . . . and more!

Carpenter steel

you can do it consistently better with Carpenter Stainless Steels for specialists



The Carpenter Steel Company, Main Office and Mills, Reading, Pa. Alloy Tube Division, Union, N. J. Webb Wire Division, New Brunswick, N. J. Carpenter Steel of New England, Inc., Bridgeport, Conn.

YOUR BEST WORK REQUIRES CLEARPRINT

CLEARPRINT

Tracing Papers have served the Engineering and Architectural profession since 1933, and the oldest tracings still serve our many friends today, as they have served for over 27 years. Clearprint Papers are watermarked for your protection.

UNIFORMITY

The Unchanging Character of CLEARPRINT Papers includes an ideal Ink and Pencil Surface—Permanent Transparency—Outstanding Erasing as well as Handling—Reproduction and Lasting Qualities. To the above we have added—Clearprint does not discolor with age.

ERASING QUALITIES OF INK AND 2H PENCIL LINES

Drawn and redrawn in the same areas prove CLEARPRINT'S unequalled erasing strength. . Please hold our erased samples to the light and be convinced.

PRINTING - HANDLING - AND LASTING QUALITIES

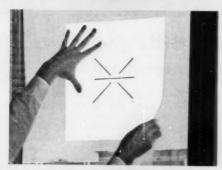
The Files of our many friends prove that CLEARPRINT originals are not subject to cracks and creases—they yield copies of fine definition.

CLEARPRINT'S VALUE TO YOU

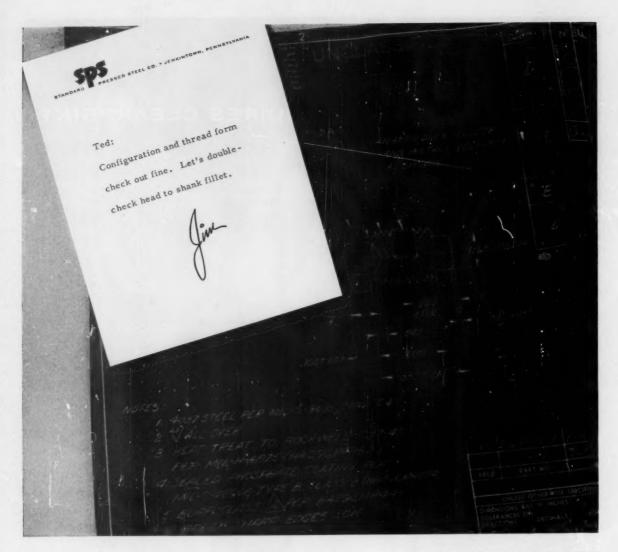
The small amount supposedly saved by buying a cheaper paper is surely of minor significance when compared to the value of the drawings involved.

WE RECOMMEND

No. 1015 for transparency • No. 1000H for regular tracings • No. 1020 and 1025 for replacing cloth. Please ask for erased samples.



CTTARRENTE ®	CLEARPRINT PAPER CO. 1482 - 67th St., Emeryville, Colif.
CLEARPHINT	Send me Clearprint Fade-Out samples, with prices, for the
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On special fasteners, SPS gives you more than just a quotation

When SPS quotes on your special threaded fastener, you get more than just an accurate estimate of cost. You also get design confirmation. Our engineering and methods people not only interpret your prints and specs; they also analyze them—carefully. And if they have any questions (socket depth, fillet radius, etc.), they double-check with you.

Certainly nobody knows all the answers on threaded fasteners. But we can say this: No one in the industry has invested more in fastener research and development than SPS . . . with commensurate results. Because of this experience, we believe we can offer a constructive or economical design suggestion where specials are concerned.

Production facilities? SPS can meet any requirement you may have in a socket-type fastener. Special configuration, special material, special threads, special plating or surface treatment, special tolerances... we are equipped to handle them all, utilizing the most advanced manufacturing and quality-control techniques.

Whatever your needs in threaded fasteners, it will pay you to check with SPS. Whether you want design confirmation or complete engineering consultation service from the outset, we make it our business to see that you get a sound, reliable part. Contact your local SPS distributor or write Standard Pressed Steel Co., SPECIAL INDUSTRIAL FASTENER Division, SPS, JENKINTOWN 18, PA.



where reliability replaces probability



From extreme specials to near-standards, SPS can meet almost any conceivable requirement you may have in configuration, material, thread form, finish or tolerances.

Product Improvement Ideas from WARNER ELECTRIC

"We design for versatility around Warner electric brakes and clutches"

Harold Hindman, President Instron Engineering Corporation Conton, Mass:

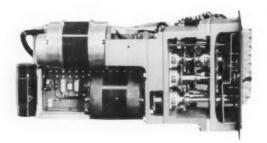






Warner Sales Engineer, Torey Montesi, and Don Holmes, Design Engineer — Search is for standard components built by specialists.

Larry Cedrone, Customer Se Encourages customer to learn



Warner electric brakes and clutches keep Instron designing ahead of industry

The gentleman who wrote: "Build a better mousetrap, and the world will beat a path to your door," sloganized a now trite but obviously sound marketing philosophy.

Instron Engineering Corporation makes this formula work. Executives of the Canton, Mass., firm plan their industrial instrument line around self-established criteria of good testing methods...almost disregard conventional concepts and equipment.

In doing so, the principles of Warner electric motion control have provided a lush feeding ground for Instron engineers eager to find new ways to increase versatility and automaticity of their equipment. Result: Valuable new tools and techniques for industry—and a growing number of customers following the path to Instron's door.

Here are specific product improvements stemming directly from Warner electric brakes and clutches:

- Increased accuracy—Four-millisecond actuation of interlocked electric brakes and clutches improves control.
- Prevention of obsolescence—Compact electric brakes and clutches permit new components to be designed as plug-in attachments for machines in the field.
- 3. Increased productivity—Pushbutton control speeds operation, makes statistical testing economically feasible.
- Versatility—Direct electrical actuation of clutches simplifies control of selsyn drive from a low-power reference unit.

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> Elim disenga movem



Leo Quintiliani, Buyer, and E. J. Tolle, Sales Manager—Customers find uses they never draamed of.



Foolproof operation—Simple electrical inrlocking of clutches and brakes guards gainst machine damage.

Reduced cost—Eighteen different speeds in be pushbutton-selected by direct actuation of clutches in new quick-change drive. complex mechanical linkages and controls are iminated.

y keeping design pressures on versatility and atomaticity, Harold Hindman, President and befounder of the company, has catapulted stron into leadership in just 14 years. Applitions for Instron testers have expanded into tality control, as well as to complex materals testing and research in various industries.

Design Engineer Don Holmes credits Warner odel 100 units for adding important sales lyantages to the Instron line. Eleven flangeounted clutches are mounted in a compact tick-change drive (left) which provides 18 fferent speeds in two ranges to the servoechanism. The technician just pushes a button change speeds.

George Burr, Vice President and Secretary, sualizes the quick-change feature as espeally valuable in the chemical and plastics dustries. With quickly changeable speeds, a ecially equipped Instron Tester can be made simulate injection-molding equipment.

Elimination of time lag for engaging and sengaging direction of travel, in stopping ovement, and in recording test data is a critical requirement at Instron. Since Warner electric brakes and clutches require only four-millisecond response, they have become an important part of Instron's new product and product improvement programs. But most important, direct electrical actuation simplifies automatic operation, permits integral control of remote integrator or recorder and tester, and provides a ready-made system for interlocking machine motions and preventing damage.

Precision instrument buyers look at controls first, so why not put proved performance where your customers see it?

Electric motion control by Warner is pioneering new concepts for nerve centers in machine design. Brakes and clutches you can hold on the tip of one finger easily control: no-load starting, multiple-drive synchronization, rapid cycling, fine-increment inching and jogging, rotary and lineal positioning, foolproof interlocking, and many other machine functions your customers look at first when purchasing or replacing equipment. That's why a Warner sales engineer can be a valuable contributor to your product improvement program.

WARNER

Warner Electric Brake & Clutch Co. Beloit, Wisconsin

planning and doing



A wild boar was sharpening his tusks against a tree. A fox passing by asked the boar why he did so. "I can see no reason why you sharpen your tusks," said the fox. "There are no hunters around, or any other dangers near us that I know of." // The wise old boar kept rubbing his tusks and replied: "Quite true, my friend, but when danger does come, I will have other things to do than sharpen my tusks."

moral: Today's planning is tomorrow's performance.

While you plan tomorrow's tooling, take a sharp look at your cylinders. High cost of machine time demands reliable performance from such components in order to compete profitably. Hydro-Line cylinders have two important new advantages to help keep your machines performing at peak efficiency, tomorrow and today.

Rod seals and wipers for our series N2 cylinders are made from Du Pont's Viton®—unsurpassed for resistance to heat and hydraulic fluids. (Viton seals and wipers are optional, at slight additional charge, on series R2 cylinders.)

Chrome-plated barrels for Hydro-Line air cylinders withstand scoring on the most rugged applications. These hard chrome-plated barrel inside diameters also resist corrosion and wear to help you avoid costly downtime and missed shipping dates.

Look in Sweet's Product Design File for dimensions of our standard stock cylinders, ready for off-the-shelf delivery. Check the address of your nearest Hydro-Line representative. Then ask him to help you select the correct cylinder for hydraulic applications to 5000 psi and air operations to 200 psi.

Viton is a registered trade-mark of E. I. du Pont de Nemours & Co. (Inc.)

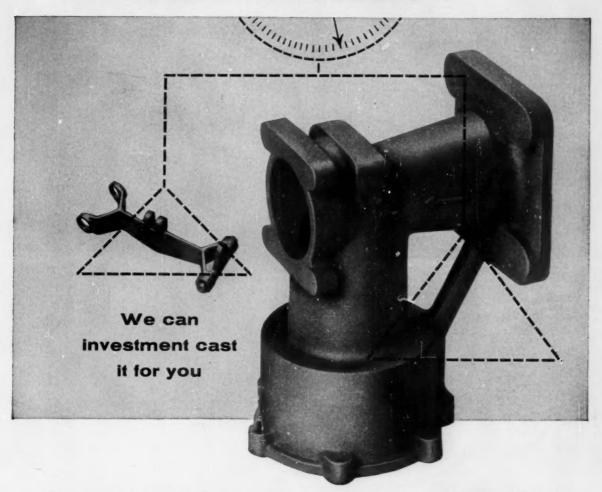


HYDRO-LINE CYLINDERS



5600 PIKE ROAD • ROCKFORD, ILLINOIS manufacturers of: high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • adjustable-stroke cylinders • dispensing cylinders • intensifiers • single-acting cylinders • booster cylinders

WHETHER YOUR PART IS TINY... OR WEIGHS 100 POUNDS...



Today, no matter how large the part on your drawing board . . . whether it weighs a few ounces or as much as 100 pounds . . . Arwood can investment cast it. It makes no difference what the metal or alloy is. We cast all castable materials, ferrous and non-ferrous, including magnesium. So now you can reap the benefits of investment casting in the broadest range of part sizes, weights and materials ever. Benefits like freedom to specify the best possible metal for the job . . . sharply reduced production costs

on complex shapes . . . quick, inexpensive tooling in design development work.

Add to these the advantage of having a single casting source for *all* your investment cast parts, both large and small.

Our five foundries can give you the metal you need, the shape you need, and the quantity you need, from a few design prototypes to many thousands.

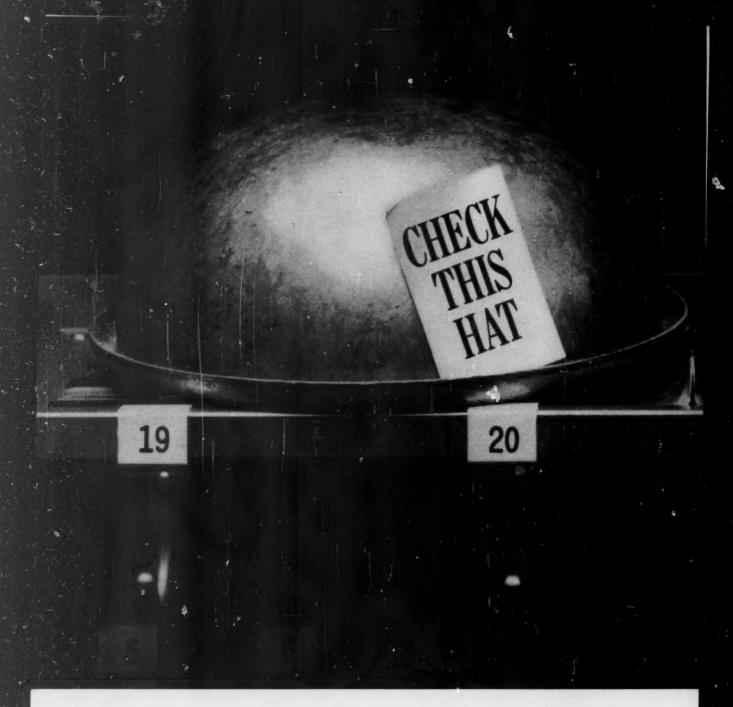
Write for your free copy of our 44-page booklet, "Practical Guide to Investment Casting."

Machine the simple . . . cast the complex

A complete service from design through tooling, production and finish machining. Seventy one engineering representatives from coast to coast.



ARWOOD CORPORATION • 315 West 44th Street, New York 36, New York PLANTS IN BROOKLYN, N. Y.; TILTON, N. H.; GROTON, CONN.; LOS ANGELES AND LA VERNE, CALIF.



Actually, this "derby hat" is a cattle-watering device, drawn from a flat sheet of 18-gage USS Galvanized Steel. We're showing it to demonstrate the severe forming USS Galvanized Steel Sheets can take without the zinc coat flaking off. Even after this deep draw, the protective zinc coating shows no signs of flaking.

Deep draws, severe forming, and 180° bends are no problem when you use USS Galvanized Steel Sheets. Here are the benefits you get: economy, ease of fabrication and excellent corrosion resistance. They all add up to a quality product. For your next job, specify USS Galvanized Steel Sheets.

United States Steel Corporation — Pittsburgh Columbia - Geneva Steel — San Francisco Tennessee Coal & Iron — Fairfield, Alabema American Steel & Wire — Cleveland United States Steel Supply — Steel Service Centers United States Steel Export Company

United States Steel



21

This mark tells you a product is made of modern, dependable Steel.









For quick access and closure...

N 1/4 TURN OPEN FASTENERS





NO. 5 STUD









Hinged and completely removable panels are secured reliably by unique Lion Fasteners which are opened or closed by a quick ¼ turn. These mil spec (MIL-F 5591A-ASG) fasteners have a high strength to weight ratio, lock smoothly with a positive grip, withstand vibration.

ALIGNMENT NOT CRITICAL

Both stud and receptacle "float" to accommodate misalignment. The hole, which retains the stud, is twice as large as the stud cross-section. This permits a float of .070 in all directions. The leaf spring receptacle also floats to accommodate stud positions.



WIDE VARIATIONS IN STACK HEIGHT

Total sheet thickness may vary as much as +.035 or -.015 without affecting operation. A Lion stud, specified for .160 total thickness, for example, will accommodate any stack height between .195 and .145.

SWAGED-NOSE STUD

Extra strength and smooth operation are made possible by the swaged-nose design. All the metal in the stud goes to work. There are no thin crosspins, holes or milled slots to weaken the cross-section. Case hardening is further assurance of long, trouble-free service.

WIDE VARIETY

Lion Fasteners are available in 3 sizes -No. 5, No. 2, and Miniature. An assortment of head styles is supplied -oval, flush, wing, ring, notched or knurled-according to individual requirements.





Send for your free copy of Southco Fastener Handbook No. 9. Gives complete engineering data on Lion Fasteners and other special fast-eners. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pennsylvania.



LION Aviation FASTENERS

















This is a "warhead". It's the front end of a carrier which darts through a pneumatic tube system at speeds up to 20 mph, and is subject to frequent shocks and impact. There's a story behind the choice of LEXAN® polycarbonate resin for this new design . . .

Formerly, destinations were set by contacts along the entire body of the carrier. Engineers of Airmatic Systems Corporation, Saddle Brook, New Jersey, reasoned that if all the control elements could be fitted into a small impactand wear-resistant head, the rest of the carrier could be designed for easy maintenance and quick replacement. Many plastics had the required dielectric strength, but none

could measure up to LEXAN resin's combination of good electrical properties, excellent dimensional stability and extremely high impact strength. LEXAN resin actually withstands over 12 footpounds per inch of notch — an impact strength attained by no other plastic!

The new warhead is injection-molded of black LEXAN resin by Berkeley Engineering & Manufacturing Co., Berkeley Heights, N. J. Now when wear and tear take their toll, the transparent carrier body is easily replaced, since it has no control elements. Also, body length can be varied to suit customer needs, and carrier weight is reduced. Printed circuits and compactly arranged brushes and con-

trol plates are used. The new design is more attractive, more practical, less costly. And—LEXAN resin warheads have proved in field tests to last longer than the old control units.

G.E. LEXAN polycarbonate resin has raised the quality of many designs to new levels. It has been reduced in price approximately 40% over the past year! Can this tough, new thermoplastic help you? Send for design literature.

LEXAN'

GENERAL ELECTRIC
Chemical Materials Dept., Section MD-11, Pittsfield, Mass.



This new engineering bulletin leads you right to the hydraulic pump designs you may be looking for. Here, passing on parade, are high performance gear pumps made to the measure of the next generation in aircraft, missiles, spacecraft, and support equipment.

Many of these units are the product of ready-made, mass-produced components that can be teamed into the precise configuration you need. Custom-designed pumps are also available.

All have in common these classic Eastern hydraulic pump characteristics:

SMALL SIZE: Eastern gear pumps are the smallest, lightest made. Airborne servo system pump shown delivers 1.5 gpm @ 1500 psig — measures only 11/8" x 11/8" x 23/4", weighs 9 oz.

WIDE PERFORMANCE RANGE: pumps available have theoretical displacement from .0016 to 1.30 cu. in. per revolution—flow from .025 to 9.6 gpm, pressures from 0 to 2000 psig, at speeds to 24,000 rpm. Weights with motor range from 1.5 to 8.5 lbs.

UNAFFECTED BY EXTREME ENVIRONMENTS: rugged, reliable Eastern units take loads to 50g in stride — shrug off temperature differentials to meet MIL specs.

Circle 446 on Page 19

EASTERN INDUSTRIES INCORPORATED

Other Eastern products:

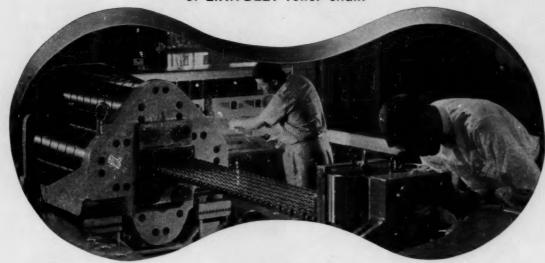
- hydraulic motors
- servovalves, amplifiers,
 actuators and systems
- actuators and systems
 pressurization/dehydration
- quick-disconnect couplings
- electronic tube cooling units







Here's
another of the
invisible extras that
insure the precision performance
of LINK-BELT roller chain



Cyclic-tension test verifies

top fatigue strength

Fatigue Resistant FR* processing of sidebars lengthens the life-span of Link-Belt roller chain. FR increases chain's endurance limit by compressing the metal around pitch holes . . . the critical sidebar areas most vulnerable to fatigue failure.

On the test equipment above—the industry's largest and fastest fatigue machine—Link-Belt has proved conclusively the superior fatigue resistance imparted to roller chain by the FR process. The machine produces up to 65 tons of cyclic tension. Rapid "stress-on, stress-off" action duplicates

toughness conditions of operation. From such facilities for research,



Single- and multiple-strand Link-Belt FR roller chains team up for dependable power transmission on tough applications.

production and quality control—plus extensive field testing—Link-Belt roller chain inherits invisible extras that withstand the grueling tensions of day-in, day-out service.

For engineering assistance in apply-

ing industry's preferred roller chain, contact your nearest Link-Belt office. See CHAINS in the yellow pages of your phone directory. Ask for Book 2657.



* U.S. Patent No. 2,517,497

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7;

LINK BELT

ROLLER CHAINS AND SPROCKETS

Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World. 15,575



THE NEW CUTLER-HAMMER SIZE 5 STARTER IS FAR MORE COMPACT THAN OTHERS

NEW CUTLER-HAMMER SIZE 5

PANEL AREA 197 SQ. IN.

VOLUME 1480 CU. IN PANEL AREA 270 SQ. IN. 37% LARGER

VOLUME 2540 CU. IN. VOLUME 2820 CU. IN. VOLUME 5750 CU. IN. 71% LARGER 90% LARGER 224% LARGER

В PANEL AREA 322 SQ. IN. 63% LARGER

C PANEL AREA 475 SQ. IN. 141% LARGER

D PANEL AREA 645 SQ. IN. 227% LARGER

VOLUME 5775 CU. IN. 288% LARGER



Now! A complete line of easyto-install Cutler-Hammer Starters including a new compact Size 5

7 sizes for use as components or as complete starters
(Size OO, O, 1, 2, 3, 4 and 5)

Now get all the advantages of Cutler-Hammer's Three Star starter line in seven sizes. You can control motors from fractional hp up to 200 hp, now that the new Size 5 is available.

The new Size 5 starter needs only an eight-inch deep case. Its open dimensions are only 13" wide, 15 3/16" high, 7½" deep . . . and is available as a non-reversing or reversing starter or as a contactor.

Even the wiring's easier. Instead of struggling to force the line and load cables into the lug connectors, the lugs unbolt, and are easily reassembled.

You still get, of course, the famous Three Star advantages that have made Cutler-Hammer Starters so famous: dependable pivoted armature, vertical contacts that don't collect dust, ease of installation, ease of inspection and maintenance, plus many other features.

Be sure to send for Pub. LO-69-A241 to get all the facts on the complete Cutler-Hammer Starter line.

What's New at Cutler-Hammer? There's a new spirit here. You can see it in the new products, the new engineering talent, the increased plant capacities. We're ready for the great growth of the sixties so you can be ready to meet the great demands upon your capacities. We'd like to tell you more. Contact the Cutler-Hammer electrical distributor or the Cutler-Hammer sales office nearest you.

WHAT'S NEW? ASK ...

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin - Division: Airborne Instruments Laboratory - Subsidiary: Cutler



HANDY & HARMAN SILVER BRAZING Permits Manufacturer to Guarantee Underwater Air Regulator For Life

Perhaps the most vital component of a skin diver's equipment, this Viking Air Regulator, manufactured by Christensen Tool & Engineering Company, Norwalk, Connecticut, is structurally guaranteed for life. It must, under all conditions, be absolutely leaktight. The manufacturer's guarantee is a relatively recent achievement—through the high-strength help of silver alloy brazing with Handy & Harman Easy-Flo 45 and Handy Flux.

Over and above the unreserved dependability of brazed joints, the brazing method itself has saved the company considerable time, money and material in the production of the Viking Air Regulator. Brazing's simplicity is interestingly illustrated in this case by this company's require-

ment that assemblers and testers of the Viking must be skin divers themselves.

Almost invariably, silver brazing effects economies and brings advantages to whatever part, product or assembly it is applied. True, air regulators are few and far between, but the point is that they are metal products, made of a number of different metal components.

And that's the phrase that covers brazing's great adaptability. To give you a good idea of how you can put brazing to work, we'd like to send you Bulletin 20—it covers the basics of brazing and it may very easily solve your metal-joining problems. Handy & Harman, 82 Fulton Street, New York 38, N. Y.

Here, in "serial" form is how the guarantee is "brazed" into the Viking:

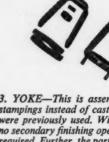


1. TANK HOUSING—Initially, this component was mechanically joined and made "airtight" by means of sealants. Now, brazing eliminates 8 holes, 4 tapping operations, 4 screws and 3 assembly operations.



Your No. 1 Source of Supply and Authority on Brazing Alloys





3. YOKE—This is assembled from stampings instead of castings, which were previously used. With brazing, no secondary finishing operations are required. Further, the part is zironger and lighter, and savings on material and labor on this component alone add up to 28%.



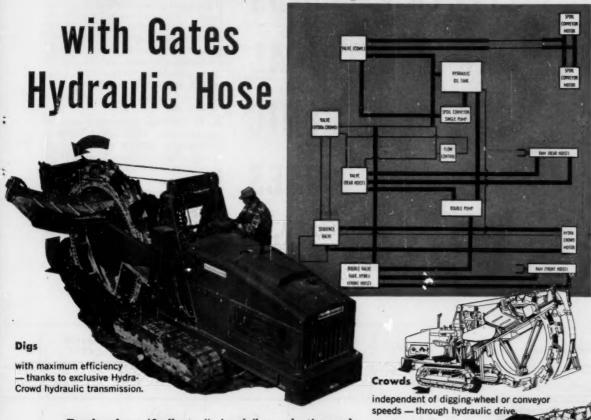
2. FORK ASSEMBLY—There are five separate brazed joints, done with hand torch and hand-fed wire. Brazing & Mminates one tapped hole, a lock washer and a spacer, plus the fact that positive alignment is now guaranteed.

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

DISTRIBUTORS IN PRINCIPAL CITIES

4. PISTON—This is the most important single element of the Viking. It regulates flow of oxygen from cylinder to mouthpiece; from 300 lbs. pressure to normal breathing. Without brazing, this part could not be made. Barber-Greene's 'educated' wheel ditcher digs, crowds, conveys, hoists...



Developed specifically to "raise daily production and efficiency while lowering operating costs on ditching jobs," Barber-Greene's Model 772 Wheel Ditcher features complete hydraulic control of all operations - an important 'first' in the entire ditching field.

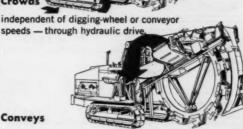
Of the Gates Hydraulic Hose used on the Model 772 Wheel Ditcher, Barber-Greene engineers have said: "Gates Hydraulic Hoses meet all of our rigid engineering specifications, and have operated to our satisfaction under the difficult conditions encountered in trenching work."

Immediately available in all major markets

Gates Hydraulic Hose - built to meet or exceed SAE specifications - is available nation-wide in wire-braided and horizontal-braided construction in a complete range of sizes, for medium-pressure or high-pressure use. Ask your nearby Gates Distributor for Gates Hydraulic Hose booklet, IH 43.

> The Gates Rubber Company, Denver, Colorado Gates Rubber of Canada Ltd., Brantford, Ontario

Gates Hydraulic Hose / Made in a Full Range of Sizes Medium-Pressure, High-Pressure



at variable speeds from 0 to 630 fpm with instant reverse - hydraulically.



swiftly, positively to hold accurate grade, prevent drifting - hydraulically.



The Mark of Specialized Research

From Monsanto FluiDesign Service...

DIELECTRIC FLUIDS FOR NEW ELECTRICAL AND ELECTRONIC

USES

Monsanto can supply you with a series of dielectric liquids that offer the optimum combination of properties for liquid cooling and insulation. Many of the fluids described below are now used commercially in capacitors, transformers, "miniaturized" electronic packages, cables, amplifiers, solenoids, thermostats, computers, and circuit breakers.

Examples:

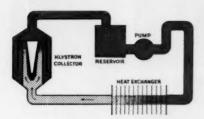
A. In electrical equipment such as transformers, Monsanto's askareltype fluids offer a series of fireresistant dielectrics. These fluids make a firesafe liquid-fill insulation for equipment that then may be located in operating areas without special precaution or costly shielding.

B. As impregnants for premiumquality capacitors, high dielectric Monsanto fluids permit a substantial decrease in capacitor size—about 50-60%—compared to oil-impregnated

Dielectric Fluids	O\$-59	Coolanol® 35	Coolanol 45	Aroclor® 1221	Aroclor 1232	
Properties			-			
Dielectric Strength, 25°C, 60 cps, 0.1	44KV	47KV	27KV	35KV	35KV	
Dielectric Constant, 25°C, 1000 cps	2.46 (106cps)		2.2 (106cps)	4.5	5.4	
Volume Resistivity, ohm-cm, 25°C	6.7x1013		9x1010	>5x10 ¹²	>5x1012	
Power Factor, % 1000 cps, 25°C	0.006 (106cps)		0.4 (106cps)	< 0.1	< 0.1	
Viscosity, CS -65°F	1380 6.8 2.2	934 6.5 2.2	2400 12.2 3.95	4.6 <1.8	6.9 <1.8	
Pour Point, °F	<-85	<-85	<-85	34	-32	
Boiling Point, °F 760 mm. Hg	>700	>600	>700	527	554	7
Fire Point, °F Cleveland Open Cup	435	430	430	349	460	
Thermal Conductivity Btu/hr/ft/ft²/°F	0.077	0.079	0.080	0.067	0.063	
Specific Gravity @25°/25°C	0.88	0.89	0.89	1.18	1.26	
Coefficient Thermal Expansion, per °F	0.00046	0.00047	0.00048	0.00039	0.00040	

capacitors. Because their dielectric constants are closer to those from the capacitor paper itself, they help achieve a more evenly distributed dielectric stress than is possible with mineral oil.

C. Monsanto's coolant-dielectrics dissipate heat and operate liquid-cooled power packs, magnetrons, traveling wave tubes, klystrons with precise temperature control. Liquid cooling with these dielectrics permits miniaturization of electronic components, conserves size and weight. These special synthetic fluids are



also lubricants, and the single fluid can double as the hydraulic-fluid activator for tuning mechanisms as well as the coolant for the electronic unit.

This schematic circuit (at left) shows how Coolanol 45 liquid cools a klystron. Pumped around the collector, Coolanol 45 absorbs surface heat from the tube wall and carries it away for dissipation in the heat exchanger.

Check the fluids shown for application in equipment you are using or developing. Monsanto can supply you with a dielectric fluid for virtually any electrical or electronic application, can be most helpful in guiding you in the early design stages of equipment that will require a liquid dielectric.

A sample of the fluids shown will be sent to you for evaluation on request. Please specify the particular fluid that interests you and state the nature of the application so that pertinent details can be sent you. For further information on available fluids, request a copy of FluiDesign Service's FLUID DATA FILE.



Simply write on your company letterhead.



Mensanto Chemical Cempany Organic Chemicals Division FluiDesign Service, Dept. 2706/ St. Louis 66, Missouri

	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260	Biphenyl	HB-40	Santowax® R
-	35KV	35KV	35KV	35KV	35KV	35KV	35KV
	5.8	5.6	5.0	5.0	2.5	2.65	2.58
	>5x1012	>5x1012	>5x1012	>5x1012	>1x1012	>5x1018	>1x1018
	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	<0.1
	17.2 2.5	45.3 3.2	46.4 6.14	75	0.98	29 3.9	****
	2	20	50	88	156	-13	293
	617	644	689	714	491	683	687
	>610	>640	>662	698	255	385	460
	0.058	0.057	0.054	0.051	0.076	0.072	0.063
	1.38	1.45	1.54	1.62	0.984	1.002	0.955
	0.00038	0.00039	0.00037	0.00037	0.00050	0.00041	0.00052

SERVICES EXPANDED TO INCLUDE PRODUCTION OF

INSTRUMENT BEARING ASSEMBLIES

By RICHARD H. CHERWIN, Executive Vice President New Hampshire Ball Bearings, Inc.

New Hampshire Ball Bearings, Inc., has established a separate facility—the Rotassembly Division—for the manufacture of instrument bearing assemblies to customer specifications. Production of shafts, housings, and pulleys of various configurations your designs may require is also included in this newest of services to instrument makers. We believe our experience in the manufacture of miniature and instrument ball bearings makes this a logical expansion of our activities.

This new service can help you if you are having problems in any of these areas:

Purchasing and handling instrument ball bearings;

Cost of assembling such bearings into units with proper fits; Cost of purchasing various components from separate sources with delays caused by un-co-ordinate deliveries;

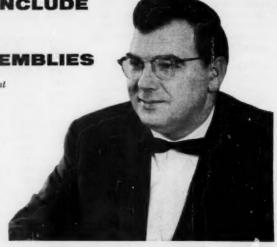
Cost and difficulty of manufacturing components;

High rate of rejects and costly tear-down of assembled endproducts to correct failures.

FREE DESIGN STUDY AND COSTING

Activity here starts from designs submitted by you. Without obligation, experienced application and production engineers, and Division technicians, study your drawings with regard to these factors: Will the bearings function as required by the application? Can selection and mounting of the bearings be modified for better performance? Is the assembly a type and size compatible with NEW HAMPSHIRE's experience and equipment?





PRECISION MANUFACTURE

Instrument bearing assemblies accepted for manufacture are produced on the same types of precision machines that equip our Bearing Facility. Employing techniques developed to manufacture NEW HAMPSHIRE Bearings to ABEC Class 7 and better tolerances, components of your unit are ground to tolerances required for proper, easy assembly. Costly rework and refitting are eliminated. Competent technicians staffing the Rotassembly Division are thoroughly experienced in custom work in cost-lowering production quantities.

ASSEMBLY AND INSPECTION FOR TROUBLE-FREE PERFORMANCE

Assembly and inspection of instrument bearing assemblies are done on the same equipment used to process NEW HAMPSHIRE miniature and instrument ball bearings. In dust-free, temperature-controlled facilities, each component of your mechanical unit is critically inspected and tested before assembly, then the unit is functionally tested after assembly. Performance levels required of them are the same as for NEW HAMPSHIRE Bearings and fitting practices followed during assembly as outlined in the "Design & Purchasing Manual." Instrument bearing assemblies shipped to you are ready for installation into your products.

MANUFACTURE IS RESTRICTED

Manufacture is restricted to mechanical units in which correct installation and function of bearings are major critical elements in the performance of the assembled unit. We are not manufacturers of gears, gear trains, gear boxes, motors or electrical components and we are not qualified to produce these items. Relationship to instrument bearings is a primary qualification for all assemblies we elect to manufacture; it is in such types that our experience can best help you.

INQUIRIES INVITED

If you wish more information about the Rotassembly Division — and our newest service to instrument makers — write or phone collect to the Regional Office in your area or the Main Plant in Peterborough.

WESTERN REGION 1540 North Highland Avenue Hollywood 28, California HOllywood 4-0208

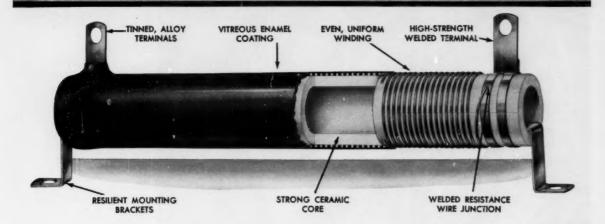
CENTRAL REGION 566 Northwest Highway Des Plaines, Illinois VAnderbilt 7-6646 EASTERN REGION 61 Cutter Mill Road Great Neck, New York HUnter 2-8633

NORTHEASTERN REGION
Route 202
Peterborough, New Hampshire
WAlnut 4-3311

NEW HAMPSHIRE

BALL BEARINGS, INC.

Quality Features of OHMITE VITREOUS ENAMELED RESISTORS



Balanced Thermal Expansion prevents crazing and moisture entrance

In Ohmite resistors, spot welding replaces soldering, brazing, and mechanical fastening. Spot welding produces strong connections that are not affected by vibration or high temperatures. Ohmite welded construction also produces an almost flush connection between the resistance wire and terminal. This prevents thin spots or bulges in the vitreous enamel coating which might cause future trouble and failure. Many different types of terminals are available besides the lug illustrated.

Ohmite can supply all of your resistor needs

some of the many types available

Brown Devil® Wire Lead

Fixed, Lug Type

Dividohm® Adjustable

Thin Type

owr-Rib[®], High Curre Round or Ribbon W Open Wound

Live Bracket Mounting

Edison Screw Base Mounting

Write on company letterhead for Catalog 58

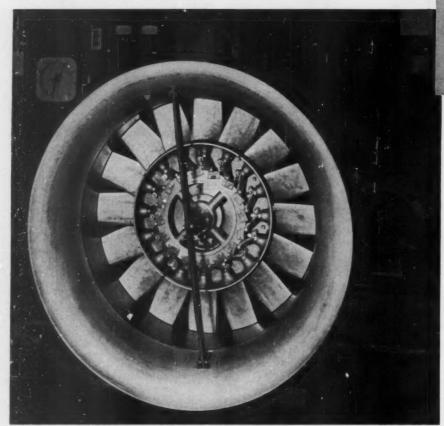
The almost endless variety of Ohmite resistors in many sizes and types-in a wide range of wattages and resistancesmakes it possible to meet each individual need. Many of these can be supplied from the world's largest factory stock. Whatever your resistor requirements may be, chances are you will find exactly the type you need in industry's most complete line of high-quality resistors.



OHMITE MANUFACTURING COMPANY 3618 Howard Street Skokie, Illinois

TANTALUM CAPACITORS TAP SWITCHES

VARIABLE TRANSFORMERS DIODES R.F. CHOKES





Pneumatic control valves permit simultaneous adjustment of the output of any number of fans. Simple mechanical linkage controls pitch of fan blades.

Joy Design Means:

REMOTE CONTROL OF FAN BLADE PITCH—FAN OUTPUT

Joy Controllable-Pitch Fans are designed to permit adjustment of fan blade pitch by remote control, in response to varying fan output requirements. A simple mechanical linkage maintains perfect calibration of all blades, and gives instant response to the control device. Blade pitch can be changed while the fan is running. The control can be manual, or the linkage in the fan can be tied to sensing devices which automatically change fan output in response to changes in humidity, temperature, CO₂ concentration, etc. Should large volumes of air or gas be involved, any number of the fans can be controlled simultaneously by means of pneumatic valves.

Joy Controllable-Pitch is much more efficient than dampers or variable inlet vanes in varying fan output. Fan motors always run at their most efficient speeds, and there are no aerodynamic losses. In addition, the basic vane-axial design of the Joy fans provides greater aerodynamic efficiency than propeller and centrifugal types.

For accurate, efficient control of variable fan output, you can't beat the Joy Controllable-Pitch Fans. Response to controls is accurate and instantaneous, and fan efficiency is high at all levels of output. For complete details, write for Joy Axivane Fan Bulle-

tin 1214-64B.



AIR MOVING EQUIPMENT FOR ALL INDUSTRY







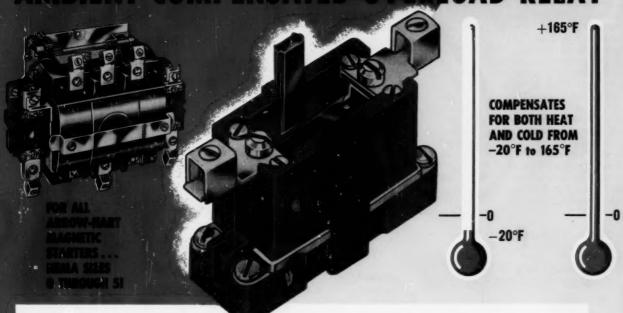




Joy Manufacturing Company Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario ANNOUNCING
Semething MEW under the sun
the ARROW (AH) HART

AMBIENT COMPENSATED OVERLOAD RELAY



RELIABLE AND ACCURATE PROTECTION REGARDLESS OF HEAT OR COLD

Here, for the first time, is a compact overload relay that compensates for both heat and cold, operating on the same time curve at all temperatures from -20°F to 165°F. Compensation is completely automatic. No field adjustment is needed. Operating mechanism is simple, rugged and dependable.

This performance is made possible by the exclusive Arrow-Hart "Balancing Bi-Metal" which is located in a separate compartment and is not; therefore, affected by heat applied to the working bi-metal.

- MUCH SMALLER SIZE . . . than any other comparable unit now available. Base size is the same as standard A-H Overload Relays.
- USES STANDARD HEATERS . . . and works equally well with either quick-trip or regular type.
- COMPENSATES AUTOMATICALLY for both heat or cold, by means of an exclusive, "Balancing Bi-Metal"

Effective through a temperature range from $-20\,^{\circ}\mathrm{F}$ to $165\,^{\circ}\mathrm{F}.$

- DEPENDABLE IN OPERATION . . . and requires no adjustments of any kind.
- AVAILABLE . . . with all A-H Starters. Ratings from 25 to 300 amperes, continuous current. Normally supplied with manual reset. If desired, relays can be equipped with a change-over lever that provides manual or automatic reset, as required.

IDEAL FOR USE ...

OUTDOORS . . . in oil fields and other installations subjected to wide seasonal or daily changes in ambient temperatures.

INDORS... for control installations located near boilers, furnaces, heating units or refrigeration equipment and subjected to wide daily changes in ambient temperature.

SEE NEXT PAGE FOR CONSTRUCTION DETAILS and ADDITIONAL DATA .

THE ARROW-HART & HEGEMAN ELECTRIC CO., HARTFORD 6, CONNECTICUT



AMBIENT COMPENSATED OVERLOAD RELAYS

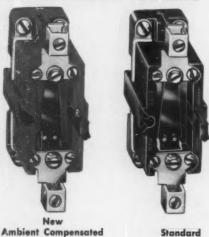
WITH "BALANCING BI-METAL"

DEPENDABLE, AUTOMATIC COMPENSATION for A WIDE RANGE OF TEMPERATURE CHANGES

As shown in the accompany the working bi-metal and the sating bi-metal are identical in construction and are joined by pling bar. As the ambient temp rises above 72°F, the compensation metal operates through the coupling to move the working bi-metal in ord to maintain its distance from the tri arm. Similarly, as the ambient temperature falls below 72°F, the compensating bi-metal operates to maintain its distance from the trip arm. Therefore, tripping time remains the same regardless of temperature. Switching mechanism itself employs the same positive snapaction featured in all Arrow-Hart Overload Relays. The calibrating screw permits precise setting. This screw is set and sealed at the factory and requires no further adjustment.

SEND NOW FOR COMPLETE INFORMATION

COMPARABLE IN SIZE TO STANDARD ARROW-HART O.L. RELAYS



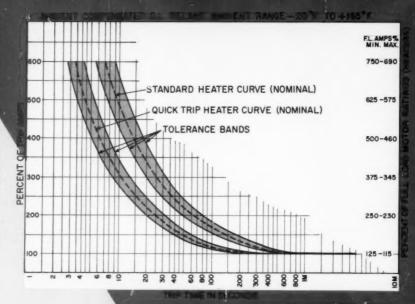
THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 Hawthorn Street, Hartford 6, Connecticut
MOTOR CONTROL DIVISION

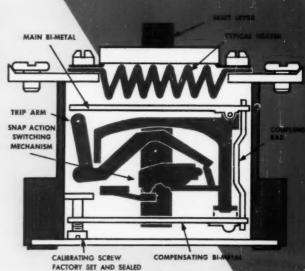
O.L. Relay

O.L. Relay

Please send me complete information on the new Arrow-Hart Ambient Compensated Overload Relays with exclusive "Balancing Bi-Metal" Mechanism.

1	,
position	
ompany	
rity	zone state





PATENT NO. 2,908,786

OPERATES ON THE SAME TIME CURVE AT ALL TEMPERATURES FROM -20°F TO 165°FI



MOTOR CONTROLS . ENCLOSED SWITCHES APPLIANCE SWITCHES . WIRING DEVICES

Born to live a short life, this missile guidance component must perform as if it had to last forever! CDF molded this part under high pressure from glass fabric epoxy laminate to meet rigid military electro/mechanical requirements. Result: a panel with excellent electrical insulating properties and high mechanical strength that provides

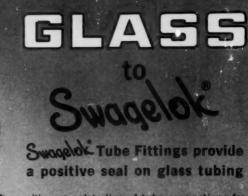
significant savings in space and weight,

helps minimize vibration.





CONTINENTAL-DIAMOND FIBRE

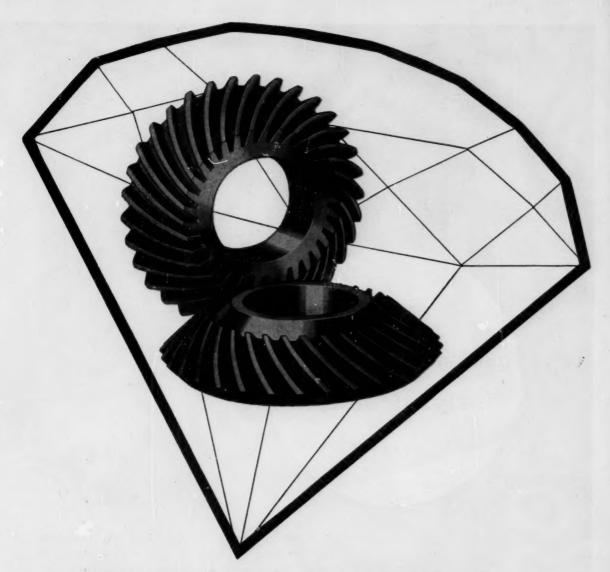


with a complete line of tube connections for laboratory work, vacuum systems and general usage. Whether your problem is connecting glass to glass, glass to metal or glass to plastic ... any installation requiring an absolute seal on glass, plastic or metal tubing —

Swagelok TUBE FITTINGS

SOLVE YOUR PROBLEMS

CRAWFORD FITTING COMPANY 884 EAST 140th ST. • CLEVELAND 10, OHIO CRAWFORD FITTINGS (CANADA) LTD. NIAGARA FALLS, ONTARIO, CANADA



Flawless in every brilliant facet...

CUSTOM GEARS AND GEAR BOXES achieve uniformly top quality in making your gearing designs precisely to your specifications.

Ask for this brochure—CINCINNATI custom gears are made in all types to 72" diameter cut teeth, 39" shaved teeth, 25" ground teeth.

better still . . . Send us your prints for quotation





CINCINNATI GEAR CO.

Cincinnati 27, Ohio Custom Gear Makers Since 1907 GEARS, good gears only 's so strange about flying saucers ...today!

flying saucers. And today, hardly an eyebrow is raised at real ones—like the modified delta-wing airplane, the Army's reconnaisance "saucer"—or the "Levicar" vehicle that hadge-hope along on a cushion of air. They use brarings—and other more or less conventional components which have been upgrated and improved—even redesigned to meet specific demands. You may have a "flying saucer"—or a somewhat less surprising something in your manufacturing future—with modified or exceptional hearing requirements. McGill quality, accuracy and reliability can assure cytimum performance—and the experience of McGill hearing engineers, available immediately at your call, can be most helpful to you right from the earliest stages of deagn. At that time, cooperative effort can produce the best combination of product and hearing research. Call a McGill engineer in early.

Write for McGill Brochurs No. 680, a billistin of facilities and abinities, it explains how we can belie you on your bearing application problems in the early stages of product resear and development.

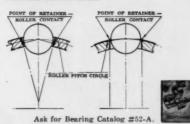


INCREASE EXPECTED LIFE UP TO 10 TIMES!

You need CAGEROL bearing performance if higher speeds and increased misalignment have prevented the utilization of needle bearing load capacity in your applications. Most important, CAGEROL bearings can deliver up to 10 times more expected life where misalignment and increased speeds exceed the capabilities of ordinary and guided needle bearings. The difference is in the exclusive McGill construction that features tapered retainer pockets for balanced roller guidance, crowned rollers, and black oxide retainer finish. CAGEROL bearings are interchangeable with all heavy duty needle roller bearings - with or without inners in two bore sizes.

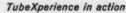
> McGILL MANUFACTURING CO., INC., Bearing Division 200 N. Lafayette Street, Valparaiso, Indiana

- Exclusive crowned roller construction, electronically gauged to insure precision contour and size uniformity. Relieved ends assure even
- 2 Flat ends fully engage integral race shoulders, provide maximum support.
- 3 Proper guidance assured by tapered retainer pockets. The design insures balanced roller support and eliminates corner wear from edge loading of straight pockets where retainer OD and pitch circle are coincident.
- 4 Simultaneously punched pockets assure accuracy of race and roller alignment. The black ferrous oxide retainer finish absorbs and retains lubrication, reducing the friction coefficient.
- SAE 52100 steel outer race has optimum hardness and surface finish.



engineered electrical products

precision needle roller bearings





Wind Velocities to Mach 7 Prove **Needle-Size Superior Stainless Tubing**

Manometer lines of Superior Type 304 stainless tubing, drawn to needle size, withstand the vibration caused by air speeds beyond Mach 7 and internal pressures as high as 5000 psi in FluiDyne wind-tunnel tests of missile component models. And they have been in some assemblies for 31/2 years without cracking, pinholing or buckling.

FluiDyne Engineering Corp., one of the major designers of such test facilities, attributes the long life of this Superior tubing to both its high modulus of elasticity and its resistance to the corrosive effects of mercury and soldering-flux acid.

Ductility is a big advantage, too. This permits the Superior tubing to be easily hand-bent into complex shapes for application in wind tunnels and readout equipment.

Filling stainless steel tubing orders that call for tiny needle tubing in gages from 6 to 33 or tubing with OD's as large as 1.125 in. calls for the resources Superior has to offer. Why not investigate us as a source of small-diameter stainless tubing. Catalog 21 describes the types and analyses available. Also gives tips on its selection and application. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

NORRISTOWN, PA.

All analyses .010 in. to 3/8 in. OD-certain analyses in light walls up to 21/2 in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FiRST STEEL TUBE MILL IN THE WEST

Mercury-wetted contact relays, steel-enclosed and ready for mo Clare reliability in operation, combined with new ease of application ar test records of over 10 billion operations, without maintenance or chan cases, they're sturdy, magnetically shielded, easily replaceable.

Choose either the standard Clare HG relay, or the HGS—super-fast an ience and increased component-density with these Clare Relay mod

ng on your own assembly line, give you ndling. Clare HG and HGS relays have characteristics. In these new modular

per-sensitive. You'll gain extra conven-

Now you can mount CLARE BILLION-OPERATION RELAYS on your own printed circuit board

Typical Clare mercury-wetted relay steel-enclosed modules for circuit-board mounting. From top: HGSM Relay Module, HGM Relay Module, HGPM Relay Module. Epoxy molded Relay Modules are also available.

Each rainy contains one or more of these magnetic switches. Mercury-wetted contact surfaces are continually writted by capillary action; they never bounce, have root dirty, never weld, and never wear nist.

Cet Bulletin CPC-8 for detailed specification characteristics, dimensions: Ask your Clare representative, or address C. P. Clare & Co. 3101 Pratt Blvd., Chicago 45, Illinois, in Canada: C. P. Clare Canada Lid., 840 Caledonia Road, Toronto 19, Onfario. Cabro address: CLARELAY.

C.P.CLARE & CO.

Relays and Related Control Components

Circle 268 as Same 10



Typical steam forging hammer

By designing with forgings, a truck manufacturer can count on the required safety factors, with minimum "beefing-up" of parts to offset unknown internal structures or non-homogenious materials.

You, too, can achieve results like these by designing with forgings either at the start or on re-design. The benefits of forgings are equally impressive, whether you make home-workshop equipment or diesel engines.

Forgings start as better metal . . . are further improved by the hammer-blows or high pressure of the forging process.

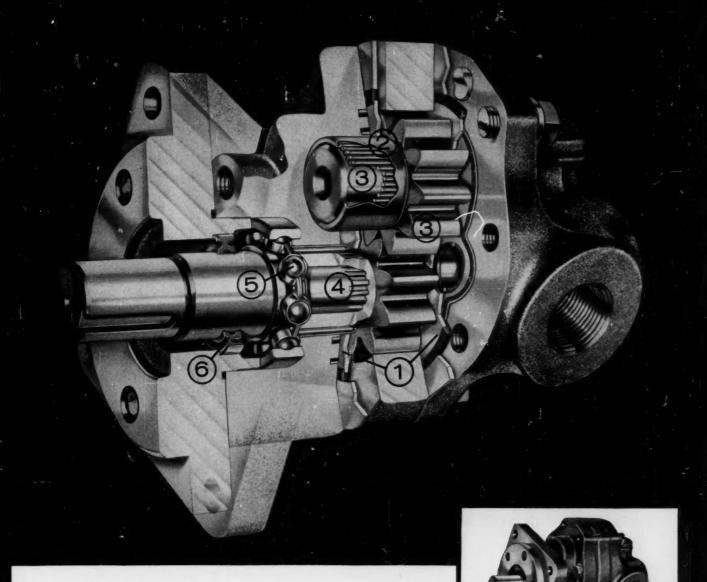
Write for literature on the design, specification, and procurement of forgings.

When it's a vital part, design it to be FORGED



Drop Forging Association • Cieveland 13, Ohio

Names of sponsoring companies on request to this magazine



Here's how webster puts new efficiency in hydraulic power

We cut this new JE series pump in half to show you why Webster design tops competition in overall efficiency. Specifically, the JE saves horsepower, slashes operating costs, delivers dependable and trouble-free service.

It's the result of this combination of advanced features....(1) pressure-balanced wear plates for high volumetric efficiency and to prevent clearance changes due to heat; (2) needle bearings for power-saving, anti-friction operation; (3) one piece gear and bearing journal units to assure minimum deflection and proper alignment on both drive and idler assembly; (4) free-floating internal spline drives to eliminate key failures; (5) thrust bearing on drive shaft to absorb compound driving thrusts; (6) double lip seal on drive shaft for added protection against seal failure and dirt.

The Webster JE series pump is a heavy-duty, big power unit built to meet the needs of the mobile industry. It is trim and compact to fit into tight quarters, attaches with a choice of mountings. Your Webster Electric representative has complete specifications and data — or write direct for engineering detailed sheet HY1-1.

JE SERIES PUMPS

Shaft seal: double lip type
Drive: direct, gear or belt
Capacity: 10 sizes — 5 to 40 gpm
Pressures: to 2000 psi
Operating Speeds: to 2400 rpm
Porting: side (std.) end (opt.)
Mounting: SAE Type A (std.)

WEBSTER ELECTRIC



Designed SPECIFICALLY for

Twin Disc, which introduced America's first torque converter in 1936, has a wealth of experience in designing converters for such applications as construction machines, oil rigs and logging equipment. But in designing the 18" converter for a new power-shift transmission package for heavy-duty vehicles, Twin Disc engineers had to solve a number of special problems.

There are long stretches when a truck does not require torque multiplication. For peak efficiency during these periods, Twin Disc has included a freewheeled stator in its new single-stage converter. When the need for torque multiplication

falls off, the speed of the pump wheel approaches that of the turbine. This reduces the reaction force on the stator to the point where it freewheels. The converter becomes in effect a fluid coupling, and the result is higher efficiency.

This efficiency can be stepped up still further under 1:1 ratio conditions by means of a front-end lock-up clutch on the converter. Engagement of this clutch provides direct drive performance.

Also featured in this new converter is a hydraulic retarder. Loads on truck service brakes keep going up, yet their capacity is limited by the available brake space at the

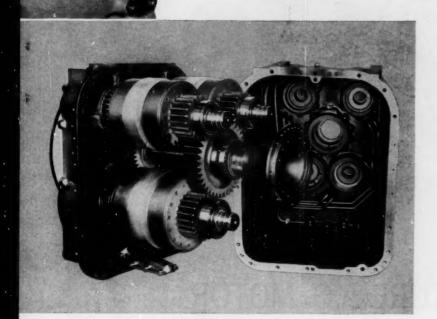
wheels. The hydraulic retarder absorbs a high percentage of the vehicle's kinetic energy, dissipating it in heat. This saves wear on the brakes and permits safe, controlled descents at higher speeds.

The torque converter can be supplied as a separate unit or as part of a converter-transmission package with the new Twin Disc TA-51-2000 Power-Shift Transmission. This transmission permits gear-shifting on up-hill hauls without power interruption or loss of momentum.

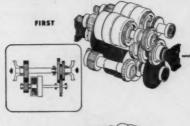
The TA-51-2000 is a straightthrough countershaft unit with constant-mesh gearing. Shifting in all ranges at full engine power is

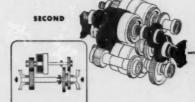
Three models available in the TA-51-2000 Series

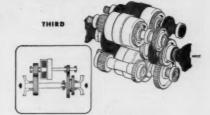
Model No.	Max. HP	Max. Torque (lbft.)	Max. Speed (rpm)	Ratio Spread
TA-51-2001	420	1050	2500	5.93:1
TA-51-2002	420	1050	2200	6.80:1
TA-51-2003	420	1050	2800	5.45:1

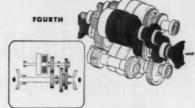


Transmission Power Flow









Vehicles...by TWIN DISC

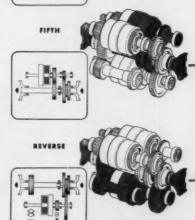
through multiple-disc, oil-cooled, hydraulically actuated clutches. There are five forward ratios and one reverse. A modified version, called the TA-33-1600, has three forward and three reverse speeds. Four different drop boxes are available to meet special drive requirements.

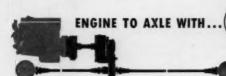
The converter is used only in the first two ranges to get the load moving or to meet low-speed tractive-effort demands. The second ratio has two selector positions, one for drive through the converter and the other for use when the converter is locked up. Lock-up range thus extends from the second through the

fifth ratio. Where desirable, a manual over-ride can be provided to permit converter drive in all ranges.

A noteworthy feature of these converter-transmission packages is interchangeability of parts. Gearing can be easily changed to match engine modifications, thereby simplifying inventories and service.

Twin Disc Clutch Company, Racine, Wisconsin; Hydraulic Division, Rockford, Illinois.









NEW MINIATURE A.C. MOTOR

high output for commercial use

This a.c. synchronous motor costs you only about half as much as its miniature precision counterpart for military applications. In production quantities it is so economical that you can design it into good quality products that now use induction motors. And because you can put this bigger performance motor in smaller spaces, it gives you a head start in miniaturizing your design at the same time you improve product quality.

Vital statistics: This Type CMC motor has a starting torque of .7 oz. in. and a continuous duty torque of .7 oz. in. at synchronous speed. It is $1^1\!\!/_4^{''}$ in diameter by $2^5\!\!/_8^{''}$ long, and weighs $6^1\!\!/_2$ oz. The shaft is precision ground stainless steel, supported by ball bearings. The epoxy-sealed design provides good resistance to normal environmental conditions.

If you have hesitated to 'design with precision miniature motors in the past, now's your chance!

The Globe motor line includes both a.c. and d.c. models. Globe is pleased to work with you to provide the exact motor you need for your commercial, competitive product. Please write for Bulletin CMC. Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio. BAldwin 2-3741.

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PRECISION MINIATURE A.C. & D.C. MOTORS. ACTUATORS, TIMERS, STEPPERS. BLOWERS & FANS MOTORIZED DEVICES



WEATHER

Fair, Mild

TOMKINS-JOHNSON TRIBUNE

THE TOMKINS-JOHNSON CO. • 2425 W. Michigan Ave. • Jackson, Michigan

INCREASED PRODUCTION CREATES PRICE ADJUSTMENT

on T-J Squair Head Cylinders

(TP)—"Due to the tremendous initial response and the continuing acceptance and purchase of the new Tomkins-Johnson Squair Head Cylinders, it has been pos-sible to lower the basic price." sible to lower the basic price," according to T-J personnel. In effecting this price cut, Tomkins-Johnson has again proven that acceptance of a quality product and the inevitable increase in manufacturing volume CAN economically justify a price reduc-tion WITHOUT jeopardizing

quality. The T-J Squair Head Cylinder, an interchangeable air cylinder for any pneumatic power application, was first introduced by Tomkins-Johnson in 1958. It was an immediate success because of

JACKSON, MICH. JAN. 3 | its availability in a wide range | of bore sizes and strokes . . . as well as the standard quality features, including the new T-J Super-Cushion for air cylinders.

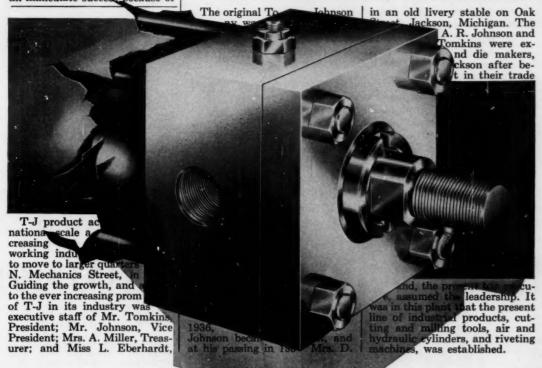
Other Standard Features
Other standard T-J features
that allow the T-J Squair Head Cylinder to retain its high quality comparison over other makes of air cylinders and still give you lower price are; solid steel heads and mounting plates, hard-chrome plated bodies and piston rods, leak-proof cylinder head to body construction, heavy duty, high tensile ground and polished chrome, plated piston rod, and many more . . . STANDARD

AT NO EXTRA COST.

Tomkins-Johnson, by virtue of the announced lower cost on its Squair Head Cylinder, wish to thank their customers for their initial acceptance which has been such a contributing factor in this price reduction.

T-J Produces Complete Line Tomkins-Johnson also pro-duces a complete line of hydraulic and pneumatic cylinders for EVERY power drive application . . . including the very popular Spacemaker. If you need further information or complete catalog material, write T-J direct, or request it from your T-J sales representative.

The Tomkins-Johnson Company was founded in 1917





- By "the world's finest" we mean the power transmission unit called the Magneclutch—Vickers name for its dry magnetic particle clutch units. And when we say "from any perspective," we're speaking of Magneclutch operating characteristics, Magneclutch reliability, and Magneclutch no-wear life . . . but most important, performance benefits that make machines equipped with Magneclutches produce more, better . . . make clutches a vital production asset instead of a "weak link".
- There are more features combined in a Magneclutch than any other industrial clutch unit... and many of these features such as no-wear, torque independent of speed, complete torque control from zero to full speed, are found only in Magneclutches. Words like grab and chatter are not in our Magneclutch vocabulary, and yet to simply say smooth operating doesn't do justice to actual Magneclutch smoothness! What's more, good design is uncomplicated design. Note the simplicity of our new low-cost units.
- Even your toughest clutch application problems more than likely have a Magneclutch solution whether involving on-off cycling, controlled acceleration and braking, torque limiting, tension control, or smooth starting and stopping. Call your local Magneclutch sales engineer or write direct to us for Bulletin 6000 if you would like to know more about Magneclutches (or Magnebrakes).

PA 6100-B

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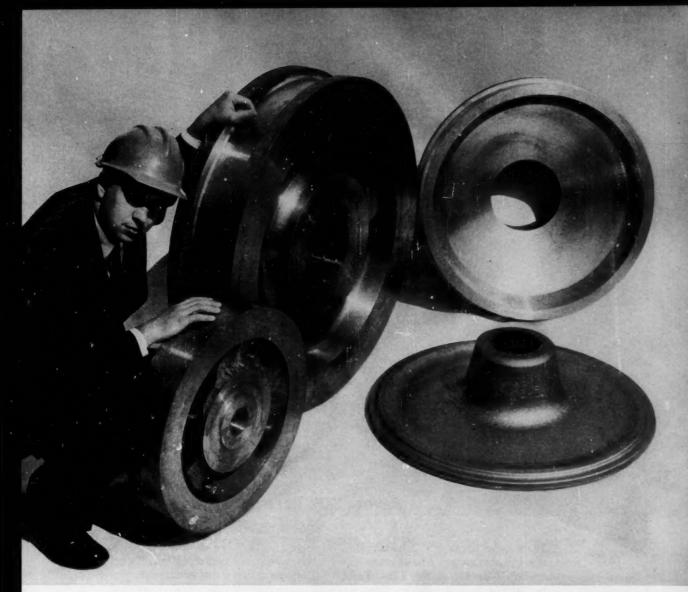
Division of SPERRY-RAND Corporation

ELECTRIC PRODUCTS DIVISION

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Bethlehem circular forgings are available in carbon, alloy, and stainless steels, and some heatresistant grades. 10 to 48-in. OD. 100 to 2,000 lb. As-rolled or rough-machined to specifications.

Which cost less, castings or circular forgings?

In initial cost, a Bethlehem circular-forged blank is competitive with a cast blank.

But that's where the competition ends.

Due to the hot working of the metal (our unique Slick Mill forges and rolls a circular product in one operation in one minute), forgings have better physical properties, greater strength than castings.

HIGHER CUTTING SPEEDS—The uniform quality of Bethlehem circular forgings allows you to use higher cutting speeds. Machining time—both in roughing, and in hobbing

teeth - is cut; tool life is increased. And there's no chance of sand damaging valuable hobbing tools.

LESS METAL—You'll find, in many cases, weight can be reduced. The greater strength of a *forged* circular product permits thinner rim sections without sacrificing strength.

Our sales engineers will be happy to give you the whole story on Bethlehem circular forgings—competitive initial cost, sure machining savings, possible weight savings, a better-quality product all around.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

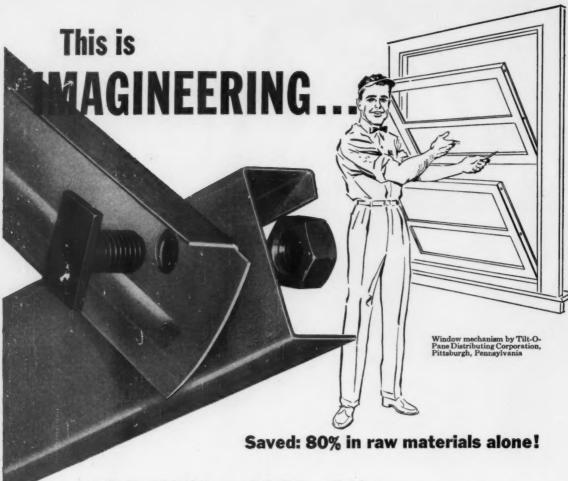
Export Sales: Bethlehem Steel Export Corporation



BETHLEHEM STEEL

Circle 468 on Page 19





We changed the design . . . a little. But, the big change was how to make this special T-head bolt for Tilt-O-Pane, the window with the hidden hinge.

Previously machined from solid bar stock, 80% of the bar became chips...scrap on the machine shop floor... and the shank and head often parted company during installation.

Screw and Bolt design engineers were able to "impact-form" this special bolt for Tilt-O-Pane from less expensive wire stock. (other bolt makers said it couldn't be done)

Result:

- · substantial cost reduction effected
- · raw material loss eliminated
- strength problem totally corrected
- window hinge reliability considerably improved
- · product assembly simplified

and Screw and Bolt's imagineering cost nothing!

Imagination, coupled with engineering, can do the same for you. If you don't know where you can use Screw and Bolt's imagineering, it's already costing you money!

SCREW AND BOLT CORPORATION



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AMERICA'S MOST COMPLETE LINE OF INDUSTRIAL FASTENERS

hoover quality

FROM START



High quality chrome alloy steel wire is produced by the Cuyahoga Steel and Wire Division of Hoover Ball and Bearing Company.

Micro-Velvet balls are produced in the Hoover Ball Division plants in Middletown, Ohio, and Erwin, Tennessee.



Hoover is actively engaged in the development of an expanded line of non-destructive electronic inspection equipment.



Hoover Quality bearings are the final result of the combined know-how of highly specialized, yet integrated Hoover divisions.



Hoover Quality, widely recognized by bearing users, is the result of complete control of every step in the manufacture of bearings.

Specialized knowledge gained through the operation of its own wire drawing mill aids Hoover in setting and controlling the quality standards of wire from which balls are made.

As America's leading producer of balls, Hoover has the experience and equipment it takes to make balls of exceptional quality. *Micro-Velvet* balls used in Hoover bearings are accurate within millionths of an inch!

And Hoover utilizes exclusive processes that assure product superiority. Hoover Honed raceways are super smooth, superbly finished. Testing and inspection at various stages of manufacturing are accomplished with specially designed equipment. Even non-destructive electronic inspection is employed.

Hoover Quality is the result of complete control . . from start to finish.

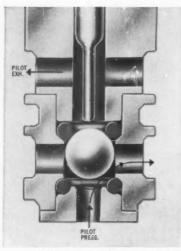
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How To Build An Air Valve That Beats Friction and Coil Heat



ENLARGED SECTION OF PILOT CARTRIDGE

To Achieve Endurance, a Breakthrough in Speed

Generally, the most unpredictable factor in solenoid valve life is the solenoid coil itself, and yet, a solenoid can be made to last practically forever if the coil can be kept from overheating. Coil heat is generated by long plunger travel and accelerated by erratic drag (friction) during that travel. Achieve a short, quick, sure plunger stroke and the coil will last indefinitely. Therefore, the life of a solenoid pilot air valve is directly related to speed of operation. To achieve operating speed, friction in the pilot section and solenoid plunger travel must be reduced to a minimum. Solve these problems and you get air control reliability that seems to have no limit.

The Call-Outs Tell the Story of Endurance

To control the major source of coil burnout, coil heating, the stroke of the solenoid plunger must be reduced to a minimum. The short stroke fractions the time the coil is energized; heat generation drops and response time of the valve is stepped up. In the "Mach 2" the stroke has been reduced to 3/32about the thickness of a nickel. Furthermore, the friction problem must be solved, to avoid any unpredictable drag. In the "Mach 2" this has been done by use of a pilot cartridge enclosing a free-moving ball that seats on "O" rings at both ends of the cartridge [see above]. The ball moves freely, independent of the seals. There is no "O" ring drag on the pilot plunger as it requires no seals. When there is no friction there is no wear. Similarly, the main valve seats seal on "O" rings. In the sealed position, metal shoulders take the shock in such a way that the "O" ring seal is merely kissed by the main valve seat [see (5) below]. As the rings are only minutely flexed they do not fatigue or lose their resilience.

What about Cycling Speed?

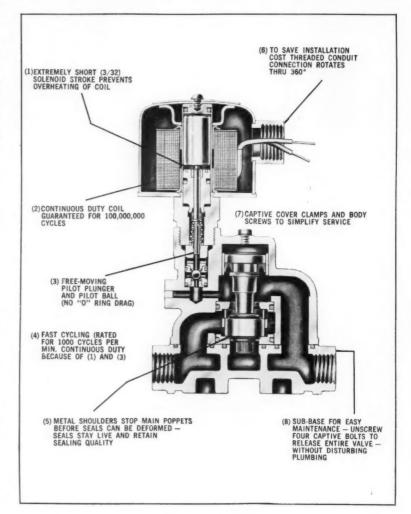
Short solenoid plunger stroke and elimination of friction make extremely fast cycling feasible. After exhaustive testing in the laboratory and on industrial applications for over six years the "Mach 2" is rated at 1000 cycles per minute continuous duty. Cycling speeds as high as 2100 have been successfully reached for intermittent periods of

twenty minutes. During a two-hour test at a sustained speed of over 1500 cycles per minute the coil temperature stabilized at 7°C below the maximum code limit for Class A coils.

100-Million-Cycle Guarantee on Solenoid Coils

The design advances incorporated in the CRESCENT® "Mach 2" Air Valve are a significant breakthrough in both cycling speed and operating dependability. Put CRESCENT® "Mach 2's" (1/4 - to 3/4 -inch pipe sizes) on your "valve killer" jobs and see how freedom from coil burnout helps to cut operating costs. Write for an advance copy of the new CRESCENT® "Mach 2" catalog to Barksdale Valves, 5125 Alcoa Avenue, Los Angeles 58, Calif.

3





January 5, 1961



Who's Narrow?

URRENT folklore has it that engineers are narrow, uncultured specialists. Their interest and knowledge in the arts and humanities are negligible, so the fable goes.

Where are those uncouth specimens? In our job-and social activities too-we meet a great many engineers from a variety of levels and industries. We have yet to find one who matches the popular image of a half-educated expert.

We suspect that engineers, on the whole, are more actively interested in literature, music, and art than are most other groups of the educated citizenry.

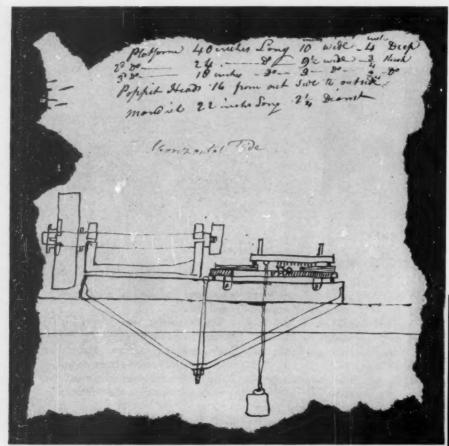
On the other hand, it is rare to find, for example, a professor of English or history or the classics with any real interest in science and engineering. Yet the impact of engineering developments on mankind today is such that ignorance or indifference here must be considered the mark of a half-educated person.

Unfortunately, too many of those who make or administer our laws are equally narrow. Political science-a misnomer-bears no relation to the engineering sciences.

Let's quit being on the defensive. Let's push the notion that what C. P. Snow calls the "two cultures" —the humanities and the sciences -are equally important elements of the intellectual makeup of a fully educated person.

The narrow specialists today are not the scientists and engineers but the humanists and scholars who refuse to face the intellectual challenges of the scientific and engineering branch of culture.

bolin Carmilael



One of Whitney's original drawings, showing a sketch and dimensions for a boring machine.

A replica of Whitney's original milling machine. It had a rotating cutting tool, against which a power-driven table moved the work.



From muskets to motorcars . . .

ELI WHITNEY'S Uniformity System

RODNEY R. ADLER

Burndy Library Norwalk, Conn. Eli Whitney was born in 1765 into a rural New England that already had traditions of mechanical resourcefulness. His father's farm had its own workshop, not uncommon in a countryside of tinkerers, to make and repair articles for house and field.

In this shop, the teen-age Whitney forged nails which found ready sale in a revolutionary America cut off from its British sources of manufactured articles. When the return of peace dumped English-made nails on the market, the future inventor anticipated his later flexibility by reconverting his backyard forge to produce hatpins and walking sticks.

With an early grounding in practical mechanics and manufacturing, Whitney combined, during three years at Yale that preceded his invention of the cotton gin in 1792 and 1793, probably the best formal education in science and technology the new nation could offer. Under President Ezra Stiles, who introduced "natural philosophy" into the university's curriculum, Whitney familiarized himself with Newton's Principia and other classics of physical science, in preparation for his future career.

In 1798, attacks on American shipping by French privateers caused a serious shortage of arms imported from Europe. With the "cold war" with France threatening to erupt into shooting at any time, Whitney recognized the need for mass production of muskets. He wrote to Congress, outlining his proposal . . .



MENTION the name of Eli Whitney, and most Americans—even engineers—think first of the inventor of the cotton gin, and only secondarily of the man who had something to do with the introduction of mass production with interchangeable parts. Yet it is the second which is by far the greatest of his contributions to the system of designing and manufacturing that sets our present industrial age apart from its predecessors in the long history of technology.

Whitney left a voluminous collection of correspondence and drawings. In addition, much has been published about his life and achievements—particularly his cotton gin. But on the subject of his "uniformity system," available records lack completeness and detail. It is difficult to determine exactly how his work dovetails with that of his predecessors, contemporaries, and successors.

Quantity production by the interchangeability system, as practiced today in industrial centers around the world, stems largely from the work of mechanically gifted pioneers in gun, clock, and hardware factories in the northeastern United States between 1800 and 1850. Of these men, Whitney has received most of the credit from historians.^{1,2}

The manufacturing methods that Whitney and his contemporaries developed in the early 1800's were as revolutionary as the war their country had fought twenty years before. Their product was one of the most intricate then in common use, one which a world unsettled by the French Revolution and its aftermath demanded in quantity—an army musket. Historical accident—France's earlier sale of 23,000 muskets of the Charleville model of 1763 to Americans fighting for independence—had made this firearm the U. S. Army standard during the decades around 1800.

The musket's design and fabrication were typical of the time. Each gun had some 50 parts, made and assembled by skilled gunsmiths. The hammer of one Charleville musket, for example, was similar

References are tabulated at end of article

to but not identical with 'he hammer of any other of the same model—a part from one musket would not fit another.

The "American System"

Whitney's idea was to break down the musket into simple components, reduce the fabrication of each part into a number of relatively simple mechanical operations, and then design and build machines to perform each of these operations rapidly and accurately.

"The tools which I contemplate," Whitney explained, "are similar to an engraving on copper plate from which may be taken a great number of impressions perceptibly alike." The "uniformity system" he advocated, based on producing quantities of identical, interchangeable parts, would be more economical than prevailing "file and fit" methods because its cost would be spread over many units.

Whitney's predecessors had created many of the elements he combined in what became known as the "American System." Robert S. Woodbury, associate professor of the history of technology at M. I. T., cites interchangeable gears for clockwork, which were machine-made and gage-checked 80 years earlier in Sweden by Christopher Polhem.

During the last quarter of the 18th century, English ironmakers like John Wilkinson were learning to cut the metal with greater accuracy. This trend culminated in 1794, when Henry Maudslay built the first metalworking lathe, with a table to hold its cutting tool steady in any position. In the 1780's the French gunsmith Honore Blanc, who may have heard of Polhem's clocks, came close to modern assembly-line methods when he made muskets with interchangeable major parts. Blanc's progress was hampered by "entrenched bureaucracy and threatened craft labor in long-established government arsenals," and finally halted by the chaos of the French Revolution.

Muskets by Machinery

In 1798, Whitney was forced to seek a new product to keep his New Haven "manufactory" busy. He had been slow in starting production of cotton gins because he had to make most of his own tools. Whitney's delays in delivering gins, the high royalty he asked, and the invention's essential simplicity encouraged crossroads craftsmen in the cotton country to ignore the loose patent laws of the time and make their own gins.

In 1798 Federalist America and Revolutionary France were engaged in a "cold war" that seemed likely to break into a shooting conflict. As on many later occasions, America found herself embarrassingly short of weapons.

French privateers were intercepting guns imported from Europe. Skilled American gunsmiths, using traditional methods in the newly established national armories or in private shops, seemed too few to produce enough muskets in time for the emergency. It was the New Haven manufacturer's opportunity. "I have a number of workmen . . . whom I have instructed in working Wood & Metals and whom I wish to keep employ'd," he wrote Oliver Wolcott, Secretary of the Treasury, in May, 1798. "I should like to undertake to manufacture ten or fifteen Thousand Stand of Arms."

He explained that forging, rolling, boring, grinding, and other operations performed by "machinery moved by water would greatly diminish the labor and facilitate the Manufacture . . ." of muskets. Only a contract for a large quantity, he stressed, would justify the investment in power-driven machinery. At the end of May he received a contract to manufacture the then-incredible quantity of 10,000 muskets of the Charleville model, at \$13.40 each, to be delivered by September 30, 1800.

Production Problems

It took Whitney more than ten years to deliver the 10,000 firearms. The building, equipping, and manning of a new plant were delayed by yellow fever in the summer of 1798 and the long, hard winter that followed, tying up supplies for construction and production. The primitive state of the industrial economy on which he depended also slowed his pioneering effort.⁵

To persuade an impatient government to extend the deadline, Whitney, in 1801, staged his historic demonstrations of interchangeability, one of which President Jefferson is said to have witnessed. Whitney disassembled ten of his muskets, mixed the parts, and then reassembled them into ten complete guns. In 1803 he began to deliver muskets in lots of 500, and shipped the last of the 10,000 early in 1809.

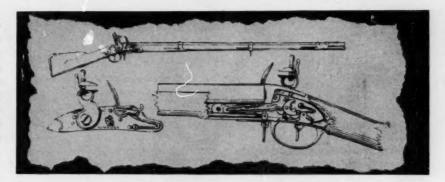
In 1812, when the enemy was Britain rather than France, the government gave Whitney his second contract, for 15,000 pieces. While filling this contract, Whitney had his historic clash with Callender Irvine, commissary general of purchases. This led to the establishment of more accurate and objective inspection standards, and the beginnings of quality control by statistical sampling.

Another Whitney experience during this period was perhaps the first instance of a conflict that has often been repeated since, between designers bent on improving a product and production managers trying to freeze designs in the interest of economy and volume. By now Whitney knew his manufacturing costs to the penny. When the government asked him to incorporate an improved flash pan in the musket, Whitney did so, but only after he had won more money, and more time to change the production setup.⁷

Designing for Mass Production

History has omitted the details, but while the Charleville muskets that Whitney first put into mass production followed the general pattern of the originals that had served the Continental Army so well, there were significant differences. He had to redesign each of its parts to be formed by a pow-

The Charleville musket, first item to be mass produced by Eli Whitney. His aim was to form every part, even the most complex, by standardized operations of forging, boring or cutting, plus grinding and polishing.



er-driven machine tool, rather than by the trained hands of a skilled craftsman. He had to establish tolerances so that any barrel would fit any stock.

Whitney not only had to redesign the product and devise the production method, but also to plan and build the machines. America had no machinetool industry in 1800. He built his plant on the Mill River in Hamden, just north of New Haven, where a 35-foot fall and an ample flow promised uninterrupted water power. He had intended to divide operations between this site and his old shop in New Haven, until Robert Orr, master armorer of the Springfield Arsenal, showed him how to save \$4,000 a year by concentrating production at the new plant.8 Some of its machinery may also have been suggested by Orr, who had succeeded in expanding the Arsenal's production from 80 to 442 muskets per month, without adding workmen.4

Unlike his contemporary, Marc Brunel, who was turning out pulley blocks for the British Navy by "one great complicated machine," Whitney used the more flexible system that predominates today, each part being fashioned by separate—and usually general-purpose-machine tools. When his plant began production, in 1801, its equipment included a power drill, a machine for boring barrels, a screw machine, and a trip hammer. A few years later a visitor described the assemblage of "Machinery moved by water, and remarkably adapted to the purpose . . . employed for hammering, cutting, turning, perforating, grinding, polishing, &c."1

In modern terms, Whitney accomplished the fabrication of interchangeable parts by using jigs and fixtures to hold the work and guide the tools, and machine tools to cut wood and metal. Possibly his greatest single contribution to the "uniformity system" came in 1818, when he combined these operations in the first milling machine, ancestor of the machine tools at the heart of today's industrial economy.10

By the following year, John H. Hall was also manufacturing muskets with machinery and interchangeable parts in the government armory at Harper's Ferry, Va. Milling machines were probably used there and at the Springfield armory by 1820.4

The Spread of Interchangeability

Within a generation after 1820, machine tools from the shops of men inspired by Whitney and other pioneers were shaping parts for clocks, revolvers, sewing machines, and reapers.

One of the most influential followers of the musket-makers' example was Samuel Colt, of revolver fame. When demand for his handarms spurted with the Mexican war, Colt arranged to have them manufactured by Eli Whitney Jr., then managing the works his father had established. Colt probably drew on Whitney's methods in planning the factory he completed at Hartford in 1853.11 According to Professor Woodbury, E. K. Root, "the technical genius behind the manufacture of the Colt revolver," also profited from Hall's achievements at Harper's Ferry.4 With 1,400 machine tools, the Colt armory was the outstanding mid-19th century example of the interchangeability system.

But of more lasting significance than Colt's revolvers were the men he trained in mass production. One of them was Henry M. Leland, who worked for Colt after the Civil War and who, in the early 1900's, applied lessons he had learned to the manufacture of Cadillac cars. In 1906, when such precision was still new to the auto industry. Leland repeated Whitney's earlier demonstration, disassembling three cars, scrambling their parts, and reassembling them before an astonished London audience.

Unlike the invention of a single machine or method, a concept as far-reaching as the principle of interchangeable parts could hardly be the sole creation of one man, however brilliant. It is rather the outcome of broad trends in technological evolution associated with the introduction of power and machinery, extending over many years and involving many men, of whom Eli Whitney was one. All of these founders of the design engineering profession contributed to the basic concept of industrial production.

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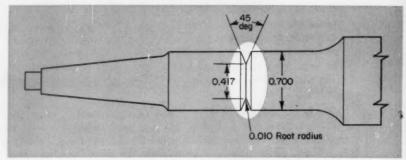
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Fig. 1-Configuration of Wohler cast-iron test specimen.

Fatigue failure of a rotating shaft is usually caused by cyclic tensile stresses that concentrate at fillets. To counteract these stresses and to improve fatigue life, residual compressive stresses can be induced in these critical

areas by . . .



Fillet Rolling

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EVERY change in section size of a rotating shaft is a potential fatigue-failure area. Stress concentrations in these areas are reduced, but not eliminated, by using large-radius fillets. The final step toward minimizing these failures involves cold working of the critical areas—actually putting a residual compressive stress in the surface layers.

The two principal methods of imparting these surface stresses are shot peening and fillet rolling. Although they perform a similar function, the processes and their results differ, Table 1.

The fillet-rolling process is used mainly to strengthen fillets of engine crankshafts. Other important uses include increasing fatigue resistance in automotive front - wheel spindles and light - alloy wheel rims, and increasing life of railroad-car axles, locomotive piston rods, and propeller shafts. Although marine propeller shafts to 36 in. in diameter are fillet rolled, the process is applied mostly to shafts less than 5 in, in diameter.

Fillet rolling involves pressing a specially shaped roller against a fillet of a rotating shaft to compress the surface layers of metal. Subsequent repeated tensile, impact, and bending stresses applied to the shaft may concentrate at the fillet, but in a properly designed part, they will not overcome the superimposed compressive stresses.

Property Changes

Rolling the surface of a fillet imparts several new properties to the metal: 1. It imposes high residual compressive stresses in the surface. 2. It work-hardens the fillet surface. 3. It improves the surface finish. 4. It may increase resistance to corrosion fatigue and fretting corrosion.

Of the many benefits that result from these property changes, the most important is the improved fatigue resistance.

Materials for shafts are usually selected on the basis of tensile strength and fatigue resistance, with lesser consideration for impact resistance. However, when an application demands a more-than-usual amount of impact resistance, the selection becomes a compromise, and some fatigue resistance must be sacrificed. Otherwise, the volume of metal must be increased to bring applied stresses down to safe levels. To overcome these problems, a steel of adequate impact strength can be fillet-rolled to a strength level that provides ample fatigue resistance

in the fillet, thereby satisfying both requirements.

Results of fatigue tests on notched cast-iron specimens, Fig. 1, show typical increased fatigue strengths for these materials, Fig. 2.1 Three 40-deg included-angle rollers, 120 deg apart, were used to roll the V-notch at 36 rpm for 5 revolutions at various pressures. Contour radius of the rollers was 0.010 in. Although nonductile flake-graphite irons received little benefit from the rolling—and even showed undesirable effects of rolling at pressures above 100 lb—the ductile nodular irons benefited greatly from the increased pressures, Fig. 3.

Residual Compressive Stress: Plastic strain occurs when a metal is stressed above its yield point. When the load is removed, residual compressive stresses remain in the metal. Before failure in tension can occur, an applied tensile load must overcome this entire residual compressive stress as well as the natural tensile strength. Also, before fatigue failure can take place, the applied alternating stresses must overcome about one-half of the sum of the original tensile strength and the superimposed residual compressive stress, Fig. 4. For example, if a fillet roller introduces 20,000 psi of residual compressive stress into a hardened steel shaft with a fatigue strength of 33,000 psi before rolling (tensile strength = 66,000 psi), the fatigue resistance will be raised to approximately 43,000 psi.

During rolling, surface layers of a metal deform—first elastically, then plastically—under compressive stress. Subsurface layers are also compressively stressed, but only elastically. Thus, low-level tensile stresses are developed deep within the work-piece to counterbalance the applied compressive stresses. When the roller is removed, the surface layers that have been plastically deformed in compression relax slightly. Beneath the surface, however, the metal stressed elastically in compression

¹References are tabulated at end of article.

cannot relax because the surface layers have taken a permanent set, and high-level residual stresses in biaxial compression remain. Compensating low-level stresses in biaxial tension exist deep within the metal.

In service, when the part is subjected to alternating tension and compression surface stressing, the residual compressive stress counteracts the applied tensile stress, and the resultant surface stress in tension is much smaller than the applied value. The resultant surface stress in compression is, of course, larger than the applied value.

Investigators have shown that fatigue failures

Table 1—General Comparisons of Shot Peening and Fillet Rolling

Shot Peening	Fillet Rolling
Shape	Limitations
No limitation	Limited to circular cross sec-
Approximately 0.025 in.	No limitation
Improved I	atigue Strength
Improvement averages 20 per cent	Improvement averages 50 per
Attainable Com:	reasive-Stress Values
	Lower (located beneath surface)
Denth o	f Cold Work
Relatively shallow— usually not over 0.020 in.	Relatively deep-0.040 in. is
Handness B	efore Processing
	Limited to Rockwell C hard-
Surfa	oe Finish
Relatively coarse	Smooth-8-16 mu in.
Lubrication o	f Part in Service
	Smooth (oil-retaining pockets can be designed in)
Time	to Process
M	asking
Necessary for protection of adjacent areas	Unnecessary

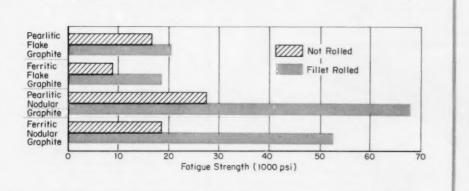


Fig. 2—Effect of fillet rolling on fatigue strength of Wohler cast iron test specimens.

are always tension failures and that they most frequently initiate at the metal surface. Also, the residual compressive stresses prevent propagation of surface cracks even if they are present at the time of rolling.

If the stress introduced by rolling is too low, only elastic deformation takes place and no residual compressive stress remains. If rolling pressure is too high, excessive deformation occurs, "ploughing up" the surface layers, overstraining the metal, and reducing fatigue resistance, Fig. 3.

Depth of the fillet-rolling compressive effect depends on applied stress during rolling, which in turn depends on load, roller dimensions, workpiece dimensions, and mechanical properties of the workpiece and roller. A large roller, under low unit stress may affect the workpiece metal to a great depth, but low residual compressive stresses are introduced. On the other hand, a roller of extremely small radius introduces high residual compressive stresses but for a relatively shallow depth. Subsequent lapping or grinding of a shallow-rolled fillet would, of course, remove the beneficial stresses.

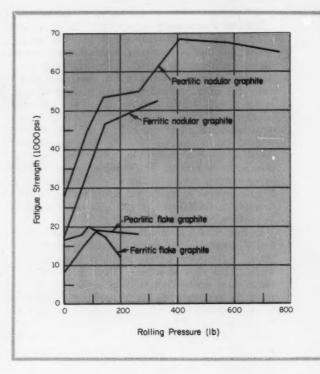
The entire fillet area must be rolled to achieve value from the process. Fillet rolling a single spot or part of the fillet defeats its own purpose by producing tensile stresses in adjacent parts of the fillet. To insure complete coverage, the roller must be passed over the fillet several times.

Work Hardening: Rolling produces a work-hardened surface which protects the fillet from damage in subsequent handling and reduces the possible occurrence of tool nicks during assembly.

Rolling has increased the Brinell hardness of B1112 steel from 140 to 195, cast iron from 185 to 260, and forged 1045 steel has been hardened from 34 to over 55 Rockwell C.² Brinell hardness of type 416 stainless steel has been increased from 210 to 273, aluminum from 102 to 122, brass from 116 to 155,³ and the Rockwell B hardness of 1040 carbon steel has been increased from 88 to 97.⁴ Cold

drawing and thermal treatments also increase metal hardness, but unlike rolling, they introduce little or no residual compressive stress at the surface.

Although many hardness traverses of fillet-rolled areas appear to show a maximum hardness value at the surface, studies of strain-hardened aluminum and copper show that maximum hardness is developed at some distance below the cold-worked surface, Fig. 5. Other investigations⁵ indicate that the plane of maximum shear stress, based on hardness readings from traverses of cold-worked metal, is at a depth d/4 below the surface, where d is the diameter of the indenter. In fillet rolling, this would be equivalent to approximately one-half of the minor or contour radius of the roller.



Applied stress
(tension)

Resultant stress
(tension cycle)

Residual stress
(compression cycle)

Residual stress
(compression)

Tension (+) Compression (-)

Fig. 3—Effect of increased rolling pressure on fatigue strength of cast-iron specimens.

Fig. 4—Effect of alternating applied stresses on residual stresses in a fillet-rolled section. Maximum residual compression stress m(-) is at depth d/4, where d=twice the minor radius (R_2) of the roller. Maximum residual tensile stress m(+) is deep within the metal. Resultant curves show shift from residual stress curve during alternating bending cycles.

Once the fillet surface has been hardened by a rolling operation performed at optimum pressure, further rolling at the same pressure cannot damage it, nor will this increase the hardness in the fillet.

Surface Finish: Although coarse-machined fillets (1000 mu in.) on steel shafts have been rolled to below 10 mu in., fillet rolling is usually performed on ground surfaces of 30 to 60 mu in., producing final finishes of 5 to 8 mu in. Roller finish largely determines the finish of the fillet, although other factors also have an influence, Table 2.

An important relation exists between surface finish and residual compressive stress: The greater the depth of compressive stress introduced, the less important is a smooth finish; conversely, where the compressive effect in fillet rolling is shallow, a high surface finish helps achieve fatigue resistance. But fatigue improvements stem mainly from increased compressive stress; much less from the smoothness of finish. Therefore, finish, in terms of microinches, is not a reliable measure of the effectiveness of rolling, Fig. 6.

Cast-iron surfaces tend to be coarser than steel surfaces when fillet rolled under similar conditions. Surface finish of nodular iron can be expected to be reduced to 10 to 15 mu in. by rolling; gray cast iron, to as low as 6 to 8 mu in. (if the effect of graphitic crevasses is ignored). For the smoothest finish, cast parts should be rolled in the machined or ground state.

Corrosion Fatigue: When a fatigue crack begins to form, tensile and shear stresses concentrate at the crack root. Chemical corrosion then removes metal from this area. With tensile restraint gone, the crack widens, introducing new, high stresses at the root, and the crack propagates rapidly, Fig. 7a.

Fillet rolling retards corrosion fatigue in a crack because the compressive surface stresses tend to close the crack, preventing entry of corrosive products and neutralizing the tensile and shear stresses at the root. This action redistributes the applied stress along the crack wall, produces new crack nuclei, and forces the corrosive environment to act laterally in directions other than that of the original crack, Fig. 7b. The multiple-crack effect lowers the stress level in the original crack, reduces the notch effect, and retards further crack propagation. Corrosion fatigue cracks in a fillet-rolled surface are detected more easily at an early stage because of their width relative to cracks in an unrolled surface.

If corrosion fatigue progresses to the point where the crack root penetrates the surface-stressed layer, crack propagation takes place rapidly in the usual manner.

Cracking of AISI 410 stainless steel (36 to 42 Rockwell C) under a 60,000 psi static stress in air-

Table 2—Factors Affecting Surface Finish of Fillet-Rolled Parts* Produces Better Finish Produces Poorer Finish Smooth finish Roller Finish Coarse finish Small Large Low High Lubricant High viscosity Low viscosity Small Feedt Large No effect No effect *In order of decreasing importance. †On wedge-shaped rollers, feed corresponds to wedge angle

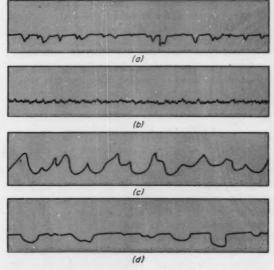


Fig. 6—Comparison of finished metal surfaces show that microinch finish readings can be deceptive. Ground and fillet-rolled surface, a, has the same finish (8 mu in.) as lapped surface b, but the saw-tooth surface of the latter can cause more rapid bearing wear. A wirebrushed finish, c (125 mu in.), can be fillet rolled and roll burnished to produce a 2 mu in. finish (on flats), d, with good oil-retaining properties.

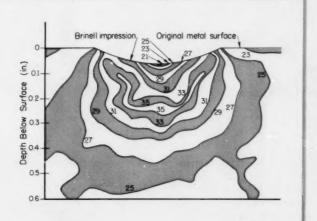


Fig. 5—Hardness distribution in strain-hardened aluminum is shown by isodurs—lines of constant hardness. Values noted are Brinell hardness numbers.

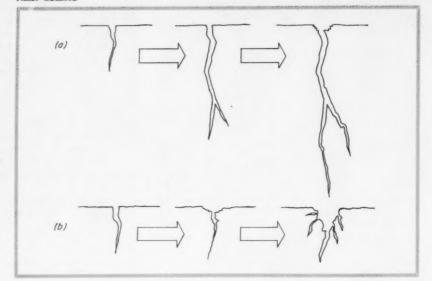


Fig. 7—Propagation of a fatigue crack in an unrolled fillet proceeds rapidly, a, under corrosive conditions. Compressive surface stress in a rolled fillet, b, tends to close crack and to redistribute applied stresses laterally.

saturated water at 300 F was retarded for 8 weeks by surface compression.⁶ Untreated parts started cracking a few hours after being placed in service. The residual stress was introduced in this case by peening, because the part surface was irregular. However, on a cylindrical part, fillet rolling or roll burnishing would have a similar effect.

Occasionally, shaft failures are traced to the transformation of residual austenite to martensite under applied stress in service. This transformation introduces localized areas of high stress which serve as fatigue nuclei. Fillet rolling can be used to prevent this type of failure by "forcing" transformation of the residual austenite before the shaft is placed in service. The residual compressive stresses also neutralize the tensile and shear stresses which may arise from continued austenite transformation during service stressing. Investigations have shown that compressive surface stressing can improve impact resistance by lowering the transition temperature of SAE 1020 steel specimens by 60 F.

The Rolling Process

To achieve the high compressive forces needed to plastically deform metal in the fillet, an alloysteel wedge-shaped roller, Fig. 8, is pressed into the fillet under hydraulic pressure. Because the contact area is small, a relatively low pressure generates ample stress to deform the material. For example, a contact area of 0.00027 sq in. produces a compressive shear stress of 650,000 psi with an applied loading of only 175 lb. Rolling with a ball or a plain roller shaped to match the fillet radius would require a much higher load because of the greater contact area. A light-oil lubricant prevents galling and helps generate a fine finish.

As the roller rotates, the narrow portion of the wedge rolls metal at the fillet center Fig. 9a. Rota-

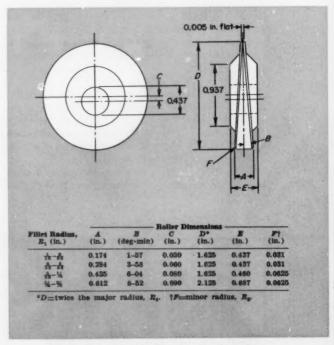


Fig. 8—Recommended dimensions⁹ of wedgeshaped roller design,⁸ for rolling small fillets.

tion away from the wedge point works the fillet metal toward its extremities Fig. 9b and 9c. As the shaft and roller rotate in contact at 150 rpm, the narrow lands on the roller circumference ride up and down each side of the fillet. Although 200 to 600 rolling cycles may be recommended to assure thorough coverage, as few as 11 cycles are used in practice to achieve significant fatigue-strength improvement.

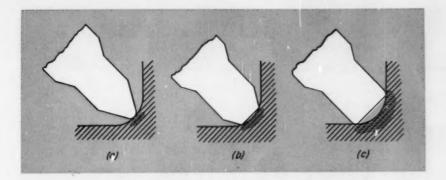


Fig. 9—Action of wedgeshaped roller cold works the center of the fillet, a, and the extremities, b and c, uniformly.

Nomenclature

- C = A function of roller and workpiece material properties (dimensionless)
- F = A function of roller contact angle θ (dimensionless)
- P = Roller pressure, lb
- $R_1 = Fillet radius, in.$
- $R_2 =$ Contour or minor radius of roller, in.
- R_3 = Shaft or workpiece radius, in.
- R4 = Roller major radius, in.
- $S_c =$ Minimum compressive stress required for desired hardness, psi
- θ = Roller contact angle (angle included by major axis of contact ellipse of roller and fillet), deg

Production-type fillet-rolling machines, Fig. 10, are used for rolling multiple fillets on crankshafts. Similar equipment is used for production rolling of wheel spindles. Larger shafts (above 5 in. in diameter) are rolled on equipment constructed especially for each application or on engine lathes equipped with rolling heads.

Surface Preparation

Although machined finishes as coarse as 125 mu in. are generally acceptable for rolling, ground finishes below 60 mu in, are rolled faster and usually produce a slightly better finish.

Of the many fillet configurations commonly used, Fig. 11, styles b, c, and d are preferred to style a for rolling, since the wedge roller causes a small

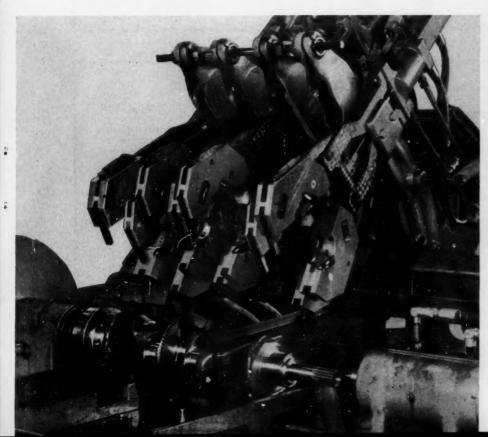




Fig. 10—Crankshafts and similar parts are fillet rolled by multiple-fillet rolling equipment on a production basis, left. Closeup of open shoe on one of the rolling heads is shown above.

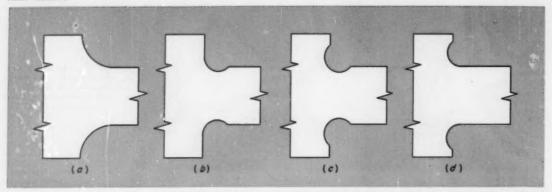


Fig. 11—Typical fillet configurations for rolling. Styles b, c, and d are preferred to style a. Undercut style d must be ground on an angular-wheelhead grinder but when fillet rolled, requires no roll burnishing to smooth the transition.

ridge of metal to build up at the edge of the rolled area. Angular clearance of the roller is generally designed to minimize this ridge formation.

One recommended finishing sequence specifies: 1. Finish grind the journal to size, leaving the fillet and cheek slightly oversize. 2. Form-shave the cheek and fillet so that shaft diameter at the fillet is slightly smaller than journal diameter. 3. Fillet roll. 4. Roll burnish to blend the fillet and journal.

Rolling Pressure

Fillet-rolling specifications must include either the desired intensity of residual compressive stress and the desired depth, or the rolling pressure, roller major radius, contour radius, and number of passes or revolutions required for thorough coverage.

Dimensional tolerance limits may be taken from Table 3, and the roller major and contour radii (for wedge-type rollers), from Fig. 8. Rolling pressure is calculated by the following procedure:

 Establish the alternating stress in the fillet. This stress may be working fatigue stress, fatigue overload

Shaft Diam (in.)	Fillet Radius (in.)	Axial Location of Fillet (in.)	Fillet Root or Journal Diam. (in.) +0.010	
1	+0.0005	±0.005		
2	+0.001	± 0.005	± 0.010	
3	± 0.0015	± 0.005	± 0.010	
5	± 0.002	± 0.008	± 0.010	
Over 5	± 0.002	± 0.010	±0.010	

Table 4-Work Hardenability of Steel, Aluminum, and Magnesium

Alloy W	Work-Hardened Condition	—Tensile Strength— (1000 psi) Work-		Yield Strength (1000 psi)		-Fatigue Strength- (1000 psi) Work-		Hardness (Bhn*) Work-	
		Annealed	Hardened	Annealed	Work- Hardened	Annealed	Hardened	Annealed	Hardened
Steel			7						
1016 1019 1029	20 12 36	60 71 72	87 84 104	41 51	85 72 78	28 35 35	43 42 45	126 147	178 169 210
1037 1045 1055	90 6 90	72 93	226 108 274	35 69	84	33 47	65 55 75	190	400 213 535
4140	6	89	102	62	90	45	51	187	223
Alumina	ım								
1100 2024 3003	H18 T36 H18	13 27 16	24 72 29	5 11 6	22 57 27	5 13 7	18 10	23 47 28	130 55
3004 5005 5050	H38 H18, H36 H38	26 18 21	41 29 32	10 6 8	36 27 29	14 12	16 14	45 28 36	77 51 63
5052 5086 5357	H38 H34 H38	28 38 19	42 47 32	13 17 7	37 37 30	16	20	47 32	77 55
5056	H18	42	63	22	50	20	22		
Magnesi	um								
M-1 AZ31X AZ51X	hard hard hard	33 37 40	35 44 45	18 22 21	26 34 34	9 11 13	10 13 14	48 55 57	54 72 71

^{*}Load, 3000 kg with 10-mm ball for steel; 500 kg with 10-mm ball for aluminum and magnesium. For steel, work-hardened condition is given in terms of reduction of area, per cent; for aluminum and magnesium, in terms of strain-hardened temper (except for aluminum 2024-736, which is a heat-treated condition).

Table 5-Values of S

Hardness, Rockwell C	Equivalent U.T.S. (1000 psi)	(1000 psi)	
20	110	350	
25	124	390	
30	142	425	
35	163	460	
40	186	500	
45	212	540	
50	245	575	
55	287	610	
60	330	650	

From Reference 10.

Table 6-Values of F

Cos θ ^a	P		
0.1	1.00		
0.2	1.05		
0.3	1.08		
0.4	1.13		
0.5	1.22		
0.6	1.35		
0.7	1.60		
0.8	2.05		
0.9	2.85		
0.95	4.3		
0.99	9.0		

 $1/R_4 + 1/R_8 - 1/R_9 - 1/R_1$ *where $\cos \theta =$ where $\cos \theta \equiv \frac{1/R_4 + 1/R_3 + 1/R_2 + 1/R_1}{1/R_4 + 1/R_3 + 1/R_2 + 1/R_1}$ and the value of R_1 is taken as negative.

Table 7-Values of C for Steel Rollers with Various Shaft Materials

Shaft Material	C	
Steel	2.06×1014	
Aluminum	5.88×1013	
Magnesium	2.15×1013	
Stainless steel	1.84×1014	
Nodular iron	1.94×1014	

stress, or repeated tension impact stress. Apply the necessary notch and safety factors to establish the mechanical strength required in the metal. Check Table 4 to be sure that the alloy has sufficient workhardening capacity to achieve the required strength level at the fillet surface.

- 2. Establish the minimum depth below the fillet surface to which the effects of working should penetrate. A graphical analysis of applied service stresses helps to arrive at a realistic value for this depth. The shallowest depth consistent with the design stresses should be selected. The contour radius of the fillet roller should be at least twice this depth.
- 3. Assume a fillet roller with a major diameter of about one-half the diameter of the workpiece. (A 1.625-in. diameter roller is usually adequate for shaft diameters of 2 to 5 in.) Pressure P (lb) to be applied on this roller can be found from

$$P = \frac{S_c^3 F \left(\frac{4}{1/R_1 + 1/R_2 + 1/R_3 + 1/R_4} \right)^2}{C} \tag{1}$$

where values of Se, required minimum stress, F, an empirical constant, and C, a function of material properties are taken from Tables 5, 6, and 7 respectively. An alternate equation for quick calculation is

$$P = 2630 \left(\frac{4}{1/R_1 + 1/R_2 + 1/R_3 + 1/R_4} \right)^2 \quad (2)$$

The value of R₁ must be taken as negative in either formula, since the center of the fillet radius lies outside the body.

- 4. Where wedge-shaped rollers are to be used, two radii are constantly in contact with the fillet; consequently the applied pressure must be 2P. When more than one roller is applied on the same head, pressure must be increased accordingly.
- 5. Establish a tentative specification at this point. A typical specification might be: Roll 0.250 fillet radius with 1.625-in. diam roller having 0.040 minor radius-150 lb pressure per roller.
- 6. Finally, determine whether the total applied pressure is within the capacity of available equipment. If pressure is too high, decrease R4 (or R2 if depth of penetration is not critical), altering the size of the elliptical contact zone between roller and fillet as needed, until a realistic pressure is reached. Or, a larger fillet radius may be specified to reduce applied roll pressure.

Although these formulas assist in the selection of approximate dimensions for rolling, the process is largely empirical. Ideally, tests should be made on sample parts to ascertain if hardness level and depth of penetration actually reached in the fillet area are adequate for the job. Where facilities are available, full-scale fatigue cr overload tests should be run.

Other Design Factors

Fillet rolling is not successful on metals harder than 40 to 45 Rockwell C, because the pressures required to initiate deformation cause rapid wear and early failure of rollers. Stellite or carbide rollers may provide a means of fillet rolling at high hardness levels

Rolling a decarburized surface has little or no effect on fatigue strength. A heat treatment should be specified that assures a minimum of decarburization in the fillet. Machining allowance must be made for the removal of all abnormal surface metal,

Fillet rolling sometimes imparts a small amount of runout (0.008 to 0.015 in.) and the part may require straightening after rolling. If the residual compressive stresses are sufficiently high, the straightening operation will have little effect on fatigue strength.

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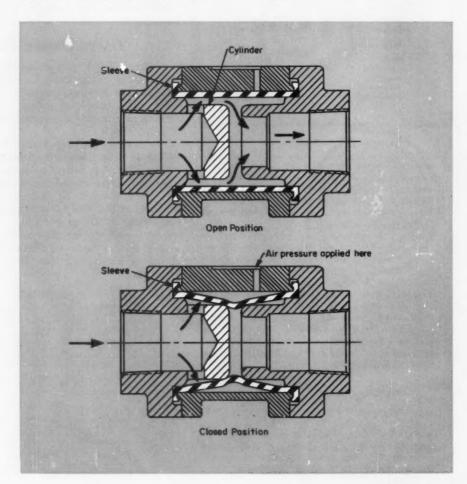
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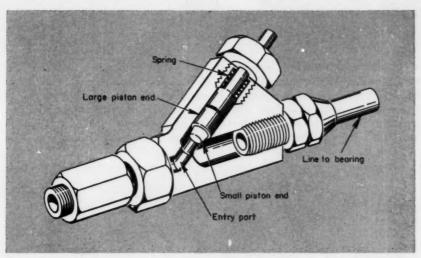
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scanning the field for ideas

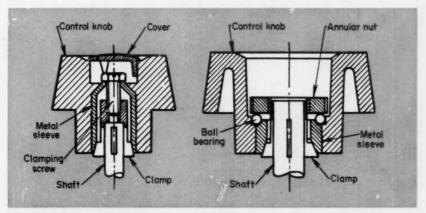
Limited-travel sleeve opens and closes valve. In operation, fluid opens the valve by forcing the sleeve against the outer walls. To close the valve, air pressure

applied around the sleeve forces it against the rounded end of the cylinder. Principle employed in valve developed by Airmatic Valve Inc., Cleveland.





Latching-action valve closes when line pressure drops and stays closed against subsequent increased line pressure. The spring-loaded piston is held open by normal pressure against the larger area to permit flow. Pressure reduction caused by a line failure beyond the shutoff permits the piston to close the entry port. Supply pressure acting against the smaller area of the piston cannot open it against the spring force. The resulting pressure increase actuates a warning device. Principle employed in broken-line indicator developed by Trabon Engineering Corp., Solon, Ohio.

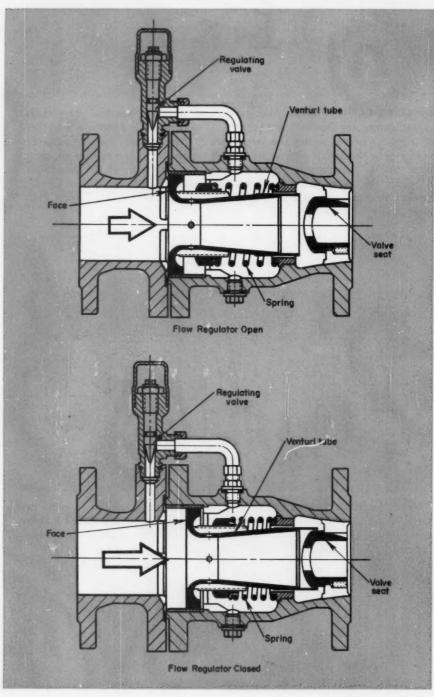


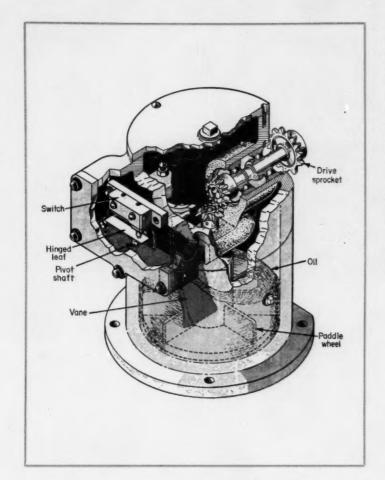
Tapered-chuck fastener squeezes shaft to attach control knob to the shaft. Axial movement of the cone forces it against a mating surface of a metal sleeve pressed into the plastic knob. Principle employed in control of knob manufactured by Valvo GmbH, Hamburg, Germany.

SCANNING THE FIELD FOR IDEAS

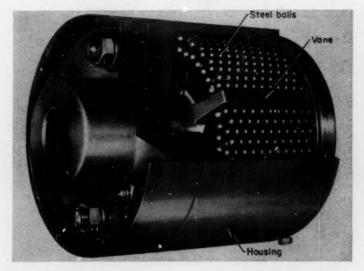
Self-positioned venturi regulates flow. Upstream pressure against the face is balanced by a compression spring to determine axial position of venturi. The spring cavity is open to lowest-pressure portion of the venturi. Any increase in

upstream pressure acts against the face, as well as reducing pressure in spring cavity, to close the throttling portion of the valve. Principle employed in flow regulator manufactured by Bopp & Reuther, Mannheim, Germany.





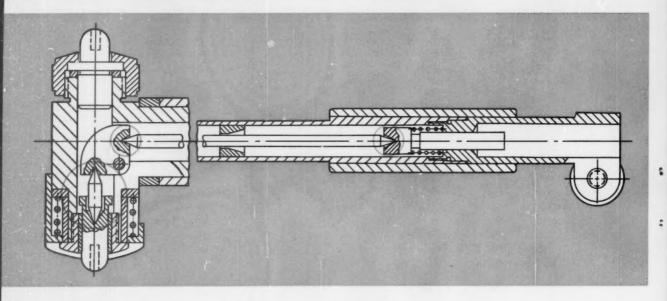
Oil-deflected vane detects presence or absence of rotation to control a safety shut-off switch. In normal operation, the paddle wheel, driven from shaft being monitored, imparts circular motion to the oil which deflects the vane. A flat surface on the pivot shaft of the vane operates the switch contact. If the paddle wheel stops, the vane drops to an upright position and operates the switch. Principle employed in a motion safety switch developed by Fuller Co., Catasauqua, Pa.



January 5, 1961

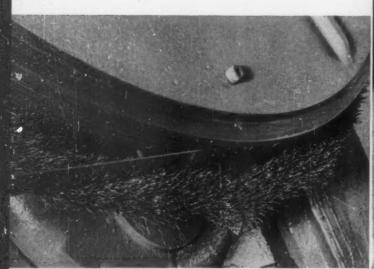
Balls transmit torque in a centrifugal clutch. Steel balls, driven by vanes connected to the input shaft, press against the wall of the housing attached to the output shaft. Friction between the balls and the housing provides the drive. Principle employed in clutch manufactured by Metalluk Johann Cawe, Bamberg, Germany.

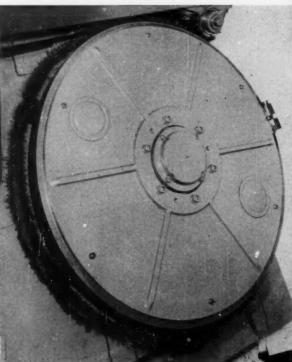
SCANNING THE FIELD FOR IDEAS



Conical rod ends in a motion-transmitting linkage reduce friction and free play. Conical recesses in mating parts permit limited angular motion. Principle employed in measuring gage manufactured by Mahr Gage Co. Inc., New York.

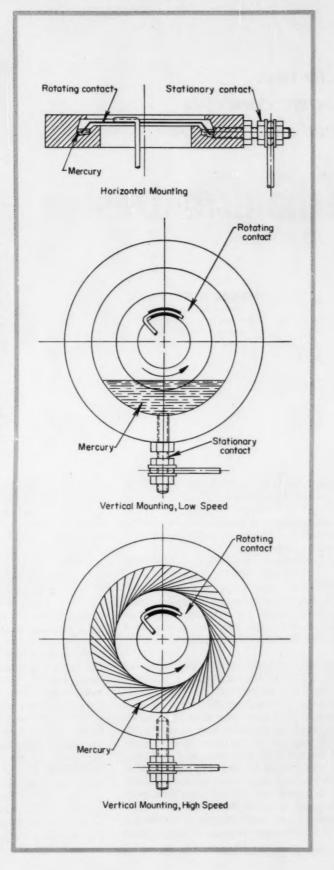
Pianetary brush sweeps across a saw blade to remove metal chips. The brush, mounted on the outer periphery of one of the guide wheels, requires no additional driving mechanism. Principle employed in saw developed by DoAll Co., Des Plaines, Ill.





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Mercury slip ring combined with a cup-shaped, rotating contact, provides constant contact resistance and freedom from sparking. The mercury is contained in a circular groove. The container can be mounted either horizontally or vertically. At high shaft speed, in the vertical mounting arrangement, viscous drag between the rotor and the mercury distributes the mercury around the groove. Principle employed in current transmitter developed by Oskar v Mossin, Duesseldorf, Germany.



How to use four basic concepts to speed and improve

Mechanism Design

4. Inversion

1. Constraint

3. Rotation

2. Toggle Effect

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PROBABLY the most useful single concept, in both synthesis and analysis of mechanisms, is the concept of kinematic inversion. An inversion of a mechanism is a mechanism obtained by fixing a different link, that is, by making a different link the frame of the machine.

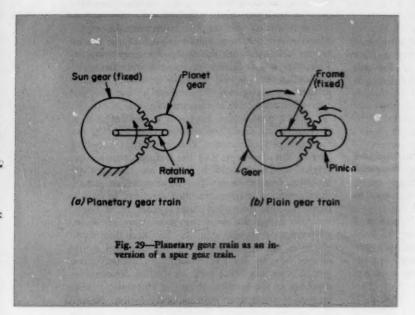
The relative motions of the links of a mechanism with respect to each other are not affected by holding a different link fixed; hence, any motion relationship involving only relative motion applies equally well to all inversions of a mechanism. Problems in both analysis and design can often be simplified by dealing with the simplest inversion of a mechanism.

One application of kinematic inversion is the determination of velocity relationships in a planetary gear train. By fixing the rotating arm which carries the planet gears and making the stationary gear free to rotate, a plain gear train is obtained which is an inversion of the planetary gear train, Fig. 29. The relative velocities of the gears can be easily determined for the plain gear train, and once they have been determined in this way, the relative velocity relationships apply also to the planetary gear train. Inversion may also be used to simplify acceleration analysis of mechanisms.¹

An example of a kinematic design problem which is simplified by kinematic inversion is the graphical layout of a cam. Here, it is convenient to consider the inversion of the cam mechanism in which the cam is fixed and the machine frame rotates backward around the camshaft.² The follower is drawn in successive positions relative to the cam, which is temporarily considered fixed, and the cam contour is drawn tangent to all positions of the follower.

In some problems, inversion can be used two or more times in succession to simplify the design solution. This is illustrated by the problem of designing a cam surface for actuating a rotary valve on a rotating drum in an automatic machine. If the valve is to be opened at a definite position of the drum, a stationary pin on the machine frame can be used to engage a cam surface on the rotary valve, Fig. 30. To design the cam in a straightforward way, first consider the drum as fixed and the pin to be rotating backward relative to the drum, to define the main geometry of the system. Then, to lay out the cam, consider the valve fixed, with the drum rotating backward relative to the valve and the stationary pin still rotating backward relative to the drum.

An inversion of the four-bar linkage, Fig. 31, can be used to provide a virtual pivot for small angular motion when a desired center of rotation is inaccessible. Such an application is shown in Fig. 32, which is a linkage designed for a dynamometer mounting. This linkage provides a close approxi-



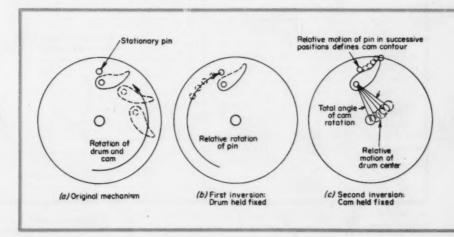


mation to a pure rotation about point P for ± 15 deg of angular motion. For this application, the small motion of the center of rotation is taken up by a flexible coupling. Points C and F are constrained to move approximately in circular paths about P. By fixing C and F to the frame of the machine and freeing link 1, P becomes a virtual center of rotation of the combination of inverted linkages.

Another application of kinematic inversion is the

extension of the applicability of computer programs for linkage analysis and design. For example, a computer program³ is now available for designing a planar four-bar linkage to approximate a desired functional relationship between the input angle ϕ and the output angle ψ , but no programs are yet available for designing a linkage to approximate a desired functional relationship between input angle ϕ and coupler angle γ . However, the available pro-

Fig. 30—Use of successive inversions to design a cam on a rotating drum.



DESIGN

grams can be immediately used for this purpose merely by temporarily considering the driving link as fixed and the fixed link as the driver. For this inverted linkage the input angle is ϕ and the output angle is $\phi - \gamma$, Fig. 33.

Summary of Design Procedure

General steps that may be followed in applying the principle of inversion of the foregoing paragraphs and the principles of constraint, toggle effect, and rotation discussed earlier in this series may be outlined briefly:

1. Use the equation of constraint (Equation 1 or 2 of Part 1) to determine the numbers of links and the numbers and types of pairs that will provide constrained motion. Then investigate the configurations which are possible with these numbers of links and pairs. In the classical theory of kinematics, this step is divided into form synthesis. Form synthesis is a listing of the types of machine elements—cranks, cams, gears, screws, friction wheels, ropes, ratchets, fluid drives, and electric drives—which may be applicable in a given problem. Number synthesis is the investigation of the configurations of these elements which

can be used to achieve constrained motion.

2. For a qualitative approach to the problem of matching the available force and motion characteristics of an input to the required force and motion characteristics of the output, investigate the toggle effects which can be achieved in each of the mechanisms obtained from the constraint considerations. This step is not found in the classical theory of kinematics, but in the author's experience it is a valuable step in giving the designer a "feel" for the characteristics of the mechanism.

3. For a quantitative approach to the design of a mechanism for prescribed motion characteristics, use the principles of rotation and inversion. The first part of this step is to find the simplest possible inversion of the mechanism and to use this simplest inversion from then on. For three precision points, the elementary graphical method described in Part 3, based on the fact that three points in a plane uniquely define the circle that passes through them, gives the most general solution. For more than three precision points, adaptations of this graphical method can be used for special solutions, but advanced graphical or analytical methods (called dimensional synthesis in the classical theory of kinematics) must be used to achieve the most general solution. Nevertheless, the elementary graphical solution is usually a worthwhile first step before applying the more advanced techniques.

In the design of a cam mechanism, the principles of constraint and inversion are still useful, but the toggle effect becomes a simple wedge effect and

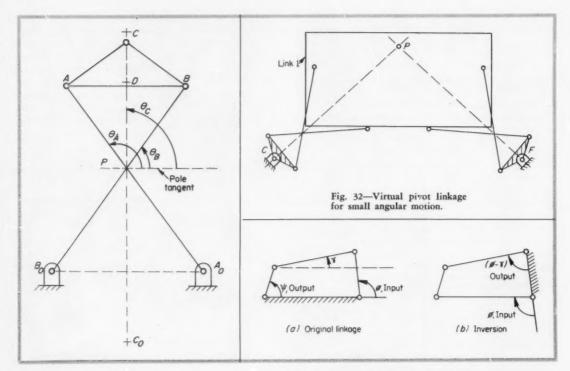


Fig. 31—Crossed four-bar linkage.

Fig. 33—Use of inversion to extend application of computer programs.

the principle of rotation, based on a limited number of precision points, is no longer required, since a cam can be laid out for an infinite number of precision points. Indeed the chief advantage of cam mechanisms lies in their versatility in meeting prescribed motion requirements and in the ease with which they can be designed.

Once the problems inherent in their design for a limited number of precision points have been overcome, however, link mechanisms can offer three

significant advantages:

Hydraulic actuators for

 They can be easily and cheaply fabricated to high precision.

They have high load-carrying capacity because of journal bearings.

 Their dynamic performance at high speeds⁶ is insensitive to minor manufacturing errors.

Putting the Four Principles to Work

A recent project illustrates how the kinematic principles of constraint, toggle effect, rotation, and inversion are applied together in the solution of

Actuator ring

exhaust nozzie Exhaust nozzle (articulated fingers) Fig. 34-Schematic of jet engine. horizontal Schedule for constant 40 actuator force from 30 (b) Schedule for 2-to-1 000 Angle, a 20 Finger Nozzle 0 60 Actuator Stroke (per cent from open position)

Fig. 35—Schedule curves for finger angle vs actuator stroke.

a design problem. The project was the design of an actuation linkage for the exhaust nozzle of a jet engine for aircraft.

To achieve optimum performance in a jet engine, the exit area of the engine exhaust nozzle must be varied during flight, as a function of flight conditions, according to a schedule determined from aerodynamic considerations. This variation can be achieved by making the nozzle out of a number of articulated fingers, pivoted on the airframe, whose free ends can be moved radially inward and outward by hydraulic actuators. To make all fingers move in unison, the hydraulic actuators drive an actuator ring, which moves axially forward and aft, and in turn drives the nozzle fingers, Fig. 34. Because of the importance of minimizing space, weight, and actuator power requirements, the design of the actuation linkage connecting each nozzle finger to the actuator ring presents a challenging kinematic design prob-

Design Requirements: To get the project underway, the requirements of the design had to be stated. The prime requirements are

- Maximum mechanical simplicity. This implies using the smallest possible number of links and joints.
- Minimum volume. The linkage must fit as closely as possible into the annular space around the periphery of the nozzle.
- Minimum weight of parts. This implies that link sizes must be kept to a minimum and that fixed pivots should not be located in places where additional substructure is required to support them.
- 4. Minimum actuator force. The main force which the actuator has to overcome is the exhaust gas pressure acting on the inside of the nozzle. This pressure increases as the nozzle area is decreased. Ideally, the actuator force should remain constant over the entire stroke. This requires a linkage with increasing mechanical advantage to overcome the increasing pressure force as the nozzle area is decreased.
- Tension stress only in rods joining the hydraulic actuators to the actuator ring. Compressive stress in these rods was undesirable because of the danger of buckling.
- 6. Minimum gain variation with stroke. Gain is defined as the slope of the curve of nozzle finger angle vs actuator travel, Fig. 35. The design of the controls for the hydraulic actuators is simplified by making this slope as nearly uniform as possible throughout the actuator stroke.
- 7. All loads to be transmitted through journal bearings. This requirement, imposed because of load and wear considerations, eliminates the possibility of using a cam mechanism for this design. Cam mechanisms have, however, been successfully employed in exhaust nozzle actuators for smaller engines.

Some of the foregoing requirements conflict with one another; hence, as in all designs, an optimum compromise was sought.

Choosing a Type of Linkage: The initial step in the analysis was to consider Requirement 1 in connection with the principle of constraint. Study was focused on the actuation linkage for a single finger, DESIGN

since the linkages for all the fingers were identical. The finger itself is a crank which rotates about the fixed pivot on the engine frame. The actuator ring was treated kinematically as a slider, since it had only axial motion. Since the linkage had a single input motion—the axial motion of the actuator ring—it had to have one degree of freedom to transmit power from the actuator ring to the nozzle finger.

Since higher pairs were eliminated by Requirement 7, the simplest possible mechanism was one with four links and four lower pairs. With a slider as the input and a crank as the output, the only possible four-link configuration was the simple slider-crank mechanism, Fig. 36. The four links were the

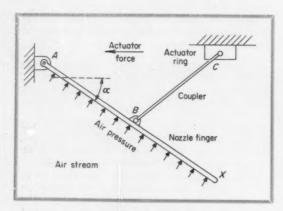


Fig. 36—Simplest exhaust-nozzle actuation linkage.

engine frame (fixed), actuator ring (slider), nozzle finger (crank), and coupler. In view of Requirement 1, this was the first linkage investigated.

The next simplest mechanism is one with six links and seven lower pairs. Such a mechanism has three links, instead of a single coupler, to join the actuator ring to the nozzle finger. The five possible configurations are shown in Fig. 37. These configurations were all investigated in turn, after it had been decided that a four-bar linkage would be inadequate.

The next simplest mechanism would be one with eight links and ten lower pairs. In view of Requirement 1, it was decided to limit the investigation to four-link and six-link mechanisms.

Determining Toggle Effect: Requirement 4 strongly suggested the use of a toggle linkage. But first the required mechanical advantage of the linkage had to be specified. Let

- F =Required actuator force per flap at a given point in stroke, lb
- M = Maximum moment on nozzle finger at a given point in stroke, lb-in.
- s = Actuator travel from minimum-area position, in.
- S = Total actuator stroke, in.
- α = Nozzle finger angle (measured from horizontal), radians

Fig. 38 shows M plotted against α . The total area under this curve is the work that must be done against pressure forces to move the finger from the maximum-area to the minimum-area position. This is also the work per finger that must be supplied by the hydraulic actuator if friction is neglected. At this stage in the design, friction is either neglected or approximated as a fixed percentage of the actuator load; later in the design, it was taken into consideration by a friction-circle analysis.

The schedule curve for the desired relation be-

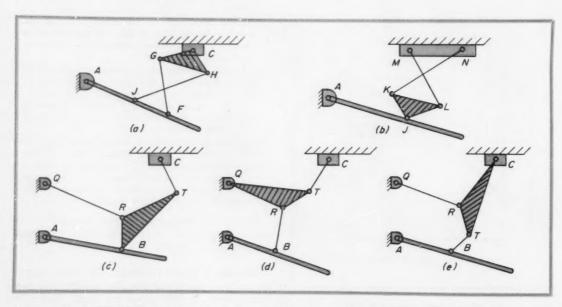


Fig. 37—Possible configurations of a six-link mechanism for converting translational to rotary motion.

tween s and α was derived by the method described in Part 2 under Design for Variable Mechanical Advantage. For any small motion ds of the actuator

$$F ds = M d\alpha$$

where friction is neglected. Therefore,

$$F = M \frac{d\alpha}{ds}$$

and derivative $d\alpha/ds$ is the gain of the linkage which converts F into M. The total area under the curve of F vs s must be equal to the total area under the curve of M vs α ; that is,

$$\int F ds = \int M d\alpha$$

The average value of F over the total stroke S was computed from

$$(F_{avg})S = \int M d\alpha$$

The minimum actuator force (optimum-force design) was achieved when F was constant and equal to F_{avg} throughout the stroke. This required that $d\alpha/ds$ be made inversely proportional to M. The resulting schedule curve of finger angle vs actuator stroke is shown in Fig. 35.

Since M varied by about 3.6 to 1 over the stroke, the requirement of minimum actuator force was not strictly compatible with Requirement 6. However, when $d\alpha/ds$ was limited to a variation of 2 to 1, the value of F required to overcome M decreased at the open end of the stroke and increased only slightly over the remainder of the stroke. Fig. 39 shows the ideal actuator force curves for the two cases; namely, Fig. 39a, an optimum force (constant) with no limit on variation in $d\alpha/ds$, and Fig. 39b, a minimum force when variation in $d\alpha/ds$ is limited to 2 to 1.

The curve of Fig. 39b was adopted for further design purposes. The resulting schedule curve of finger angle vs actuator stroke is shown as the

curve of Fig. 35b. Thus the design problem was reduced to the problem of mechanizing this curve with the simplest possible linkage.

Fixing the Slider Stroke: At this point stroke S had to be specified. This choice was a compromise between Requirements 2 and 4, since F_{avg} was inversely proportional to S. For this design, strokes of 6, 8, and 10 in, were considered, and a sixinch stroke was used in the final design.

In this connection, it should be noted that if the supply pressure to hydraulic actuators is fixed, the required piston area is proportional to F_{max} . Thus the efficiency of utilizing the energy in the oil was equal to F_{avg}/F_{max} .

The four-link mechanism of Fig. 36 provided the required toggle effect, since its mechanical advantage increases rapidly as α decreases. However, a velocity analysis revealed that over the required 38 deg rotation of the finger, the toggle effect was too great; the gain variation was much larger than 2 to 1 and could not be reduced to a reasonable value in the space available, without reducing S to about 2 in., which would have made F unreasonably high.

A second method of investigating the four-bar linkage, which proved useful also in investigating six-bar linkages, is an overlay method combining the principles of rotation and inversion. The six-inch actuator stroke is divided into half-inch intervals, denoted by positions 1 through 13. Then, with point A considered fixed, several different points C, C', C'', etc., are considered as possible locations for the actuator-ring pivot C. These points are then plotted in positions 1 through 13. The nozzle finger AX is then drawn in positions 1 through 13, using values of α obtained from the schedule curve. Then, using vellum, a plot is made of the paths of C, C', C'', etc., relative to the nozzle finger AX. This is

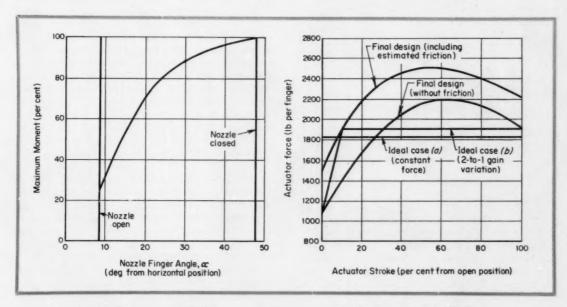


Fig. 38-Moment on nozzle finger.

Fig. 39-Nozzle actuator force.

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done by drawing AX on the vellum and then aligning it with AX_1 on the original sheet and tracing through points C_1 , C_1 , C_1 , etc., onto the vellum. Next, AB on the vellum is lined up with AX_2 on the original sheet and points C_2 , C_2 , C_2 , etc., are traced onto the vellum. If one of the points C, C, C, etc., traces out an arc of a circle on the vellum,

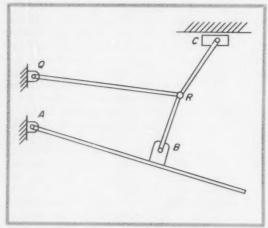


Fig. 40-Modified six-link mechanism.

the center of this circle can be used as the location of moving pivot B and radius BC can be used as the length of the coupler. In this investigation there were several locations of C which had approximately circular-arc paths for the desired schedule curve, but the centers of these arcs were all far below the nozzle finger in the airstream. Since it was impossible to locate a moving pivot in the airstream, a four-link mechanism meeting the desired schedule curve was impossible.

Evaluating Six-Link Mechanisms: The next linkages investigated were the six-link mechanisms, Fig. 37a and 37b, which contain crossed four-bar linkages of the type shown in Fig. 31. They have an advantage over the other six-link mechanisms in that they have no additional fixed pivot. The linkage of Fig. 37a was investigated by kinematic inversion, and an attempt was made to match the curves of possible paths of C relative to the nozzle flap by means of the linkage FGCHJ.

When this linkage is made symmetrical, C can be located to make a circular arc with a radius equal to about twice the distance from C to base line FJ. This located the center of curvature of C in the airstream well below the finger, as is desired, but the path of point C on link ABC departed from the desired path too far at the end of the stroke. The forces in the connecting links also became high at the ends of the stroke.

The linkage of Fig. 37b was investigated by kinematic inversion, but this time the paths of possible pivot points J on the finger were plotted relative to the actuator ring. It was found that the desired

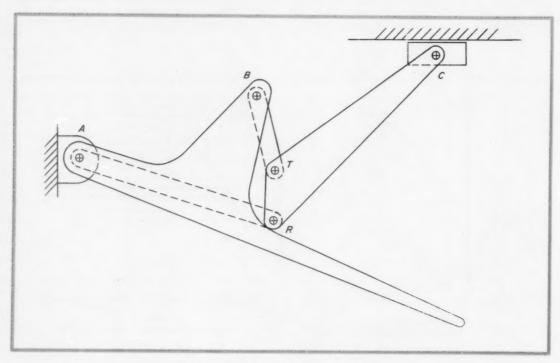


Fig. 41-Final design of actuation linkage.

paths were concave downward, whereas paths achievable by linkage MLJKN are concave upward. Therefore, this linkage could not be used.

Of the remaining three six-link mechanisms, all of which have an additional fixed pivot at Q, the mechanism of Fig. 37c was discarded because the stresses in a linkage of this type are excessively high. When the actuator is closing the nozzle, short lever arm RB produces a high tensile force in intermediate link QR and a high compressive force in nozzle finger AB. For the most part, these forces simply oppose each other rather than do useful work.

The next basic type studied was the six-link mechanism of Fig. 37d, which consists of a four-link slider-crank mechanism CTQ in series with a fourlink crank mechanism QRBA. By scaling up and rotating the four-lnik mechanism QRBA so that QR coincides with QT, the simpler mechanism of Fig. 40 is obtained without any loss in generality of possible motions. The design technique used is fairly straightforward. The initial step is to select the input slidercrank that will most nearly meet the desired scheduled curve and still stay within the design space restriction. This can most easily be done by a series of successive graphical approximations.

By making the input slider-crank approximate the desired schedule curve as closely as possible, the design of the second four-bar linkage is correspondingly simplified. By measuring the input-output curve of the slider-crank and comparing it with the desired over-all schedule curve for the nozzle, the schedule curve for the second four-bar linkage can be determined. This second four-bar linkage may then be designed by a combination of rotation and inversion. In general, for this application, three precision points give adequate accuracy.

This type of linkage has the disadvantage that it requires a second fixed pivot. This is not a serious problem and the design could have been used if it proved necessary. In view of subsequent designs, however, in which the second fixed pivot could be made to coincide with the fixed pivot of the nozzle finger, this design type was considered no further.

The design type that proved to be most suitable for this application is illustrated in Fig. 37e. As in the case of the design of Fig. 40, this design consists of a second linkage in series with the input slider-crank. In contrast to the design of Fig. 40, the output link is driven from a point of the coupler of the slider-crank rather than from its output crank. This permits the pivot for the nozzle finger to coincide with that of the slider-crank, eliminating one fixed pivot, Fig. 41.

With slider-crank ARC chosen to match the desired schedule curve as nearly as possible within the space limitations of the nozzle, and with the nozzle finger laid out in its desired sequence of positions, the design problem is reduced to the problem of locating pivots T and B so that the nozzle will come as close as possible to meeting the desired schedule curve. This problem is best approached by using kinematic inversion to lay out the motion of coupler CR relative to the nozzle flap.

With this inversion, two methods were used to

obtain solutions for the locations of T and B. For the optimum-actuator-force design, the circle-point curve, Part 3, was used to find locations of T for four precision points. For the design with gain variation limited to 2 to 1, trial points T on the coupler were selected. Denoting the two end positions of T by T_1 and T_2 , any point on the perpendicular bisector of T_1T_2 would be a possible location of B for two precision points. By successive trials, B was located as the point on the bisector which gave the desired 2-to-1 gain variation. The freedom in the location of T was used to optimize the design.

Final Design: Several alternative designs were drawn up using different points T, and the forces in the links at several positions were determined graphically, first without friction and then with friction, using a friction-circle analysis with assumed values of pin diameters and friction coefficients. The design selected, Fig. 41, had a 2-to-1 gain variation. Its actuator force curves, with and without friction, are shown in Fig. 39 for comparison with the theoretical curves.

In conclusion, the foregoing design project provided a final linkage with an estimated reduction of 30 per cent in total weight of parts and an estimated reduction of 40 per cent in maximum actuator force as compared with a previous trial-and-error design.

ACKNOWLEDGMENTS

The linkage of Fig. 41 was developed by Mr. R. S. Aronson, whose aid in carrying out this design project is gratefully acknowledged.

This article is based on a paper presented at the Sixth Conference on Mechanisms, cosponsored by Purdue University and Machine Design, October 10-11, 1960.

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Converting Curves to Straight Lines

In "Converting Curves to Straight Lines," pp. 178-179, Nov. 10, 1960, the charts in Fig. 8 and 10 should be interchanged.

They Say . . .

"Some people doubt whether the supply of young talent will hold out, they say we are scraping the bottom of the barrel. I do not agree, I think the barrel has a false bottom and there is a lot of good stuff still in it."-Sir Patrick Linstead, Rector of the Imperial College of Science and Technology, London, England.

AC MOTOR CONTROL-2

Across-the-Line Starting

How to select controls for single-speed squirrel-cage motors



Fig. 1—Typical manual starter and representative circuit applications.

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Staff Engineer

and

ARTHUR S. NEWMAN Jr.

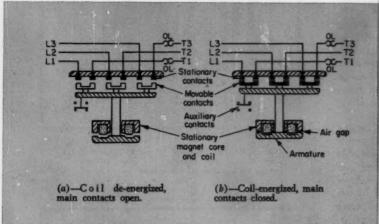
Application Engineer
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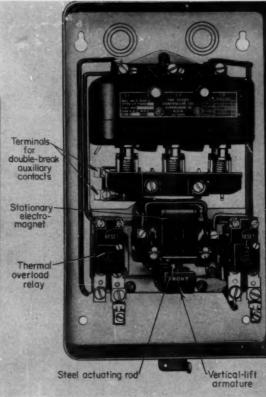
ONTROLS for single-speed drives are available in several basic types of starters. The types covered in this article, the second in a series on ac motor control, are manual, magnetic, combination, and reversing starters. As indicated by the term, "across-the-line," these starters are designed to apply full line voltage directly to the motor windings.

Manual Starters: If a control for a simple, small-motor application is being considered, the first logical choice would be a manual type of starter, Fig. 1. A small grinder is an example of the type of job for which the manual starter is suited. The motor, being small, involves no special operating characteristics or power supply problems such as heavy starting current. Special situations—reversing, multispeeds, duty-cycling, remote control—are not encountered. Also, because of the nature of the machine, there is no necessity for frequent starting and stopping.

The manual starter is simply a hand-operated contact or switch mechanism that makes and breaks the motor electric circuit. A thermal protective device included in the starter automatically guards the motor against excessive currents, Fig. 1a and 1b.

Fig. 2—Typical vertical-lift magnetic starter and cross sections of contactor and magnet assembly.





Manual starters are used to start, stop, and protect small ac motors if the job requires:

- 1. Uncomplicated performance.
- 2. No remote control.
- 3. No undervoltage protection.
- 4. Limited or infrequent operation.
- 5. Overload protection.
- 6. Low-cost control.

These conditions apply to single-phase motors up to 5 hp and to three-phase motors up to $7\frac{1}{2}$ hp at 440 v. It is obvious that the manual starter is limited in its application.

Magnetic Starters: The most desirable alternative to the manual starter is the magnetic starter, Fig. 2. Although the cost is greater, the magnetic starter is very flexible in controlling all types of motors in many different ways, including provision for undervoltage protection. In addition, it is capable of withstanding frequent, hard use.

The design of a magnetic starter is quite simple in principle. Like the manual starter, it contains a mechanism for opening and closing a set of contacts in the motor circuit and a thermal overload protective device or devices. However, while the contact mechanism of a manual starter is actuated by an operator, contacts of a magnetic starter are closed by an electric signal from some control device such as a pushbutton.

As shown in Fig. 2a and 2b, the mechanism of a vertical-lift magnetic starter consists of two sets of main contacts (stationary and movable) and a magnet structure. The magnet structure includes a stationary magnetic core, a coil that fits on the core, and an armature.

When the contactor coil is energized, a magnetic flux is established. This flux, concentrated in the iron core, draws the armature upward. Since the movable contacts are fastened to the armature by a rod, they also move upward to the stationary contacts and thereby close the circuit to the motor through appropriate thermal overload devices.

When the coil is de-energized, the weight of the armature causes it to drop and open the contacts in the motor circuit. A slight air gap is maintained between magnet core and armature in the closed position to prevent residual magnetism from holding the armature closed when the coil is de-energized.

Circuit application of a magnetic starter is illustrated in Fig. 3. Low-voltage release is provided by

a maintained-contact pushbutton. When the start button is pressed to complete the control circuit, the starter coil is energized and closes the main contacts in the motor circuit. If a low-voltage condition occurs in the power supply, the magnetic strength of the coil is sufficiently weakened to permit the contacts to open and stop the motor. When voltage returns to the proper value, and since the pushbutton contacts remain closed, the coil again closes the main contacts in the power circuit.

Low-voltage release is an advantage in many situations. For example, this feature would permit a ventilating blower fan to operate all day without attendance except for starting in the morning and stopping at night. If supply voltage were subject to frequent drops, having to press the *start* button to restart the fan every time would soon become a nuisance.

Most of the time, however, low-voltage release is not desirable because it threatens the safety of operating personnel. If a machine were to stop because of reduced voltage and the operator began to trouble-shoot the difficulty without remembering to press the stop button, he could be injured if voltage returned to normal. To eliminate this danger, another method of motor control is provided.

A momentary-contact pushbutton is used in combination with a set of normally open auxiliary contacts in the starter, Fig. 4. When the start pushbutton is pressed, the control circuit is energized and causes the main and auxiliary starter contacts to close. When the start button is released and its contacts open, the auxiliary starter contact, which is wired in parallel, continues to maintain the circuit. Consequently, the circuit containing the auxiliary contact is commonly referred to as a holding circuit.

Power interruption or reduced voltage will deenergize the coil in Fig. 4, thus dropping the contactor out and opening the holding circuit. When power is restored, the motor cannot restart automatically. The *start* button must again be pressed. The safety feature provided by this arrangement is called low-voltage protection and is one of the important advantages of magnetic control.

Flexible control is another feature of the magnetic starter. A pushbutton for energizing the starter coil can be located any distance from the starter, on the motor, or on the driven machinery. Also, use of several pushbuttons can provide multiple-location operation of the same starter and motor. Instead of a pushbutton, a limit switch, relay, timer, or pressure or float switch could be used to provide automatic operation in addition to remote control.

Starters with Disconnect Switch: As previously illustrated, a complete basic motor-control system includes: 1. Motor protection. 2. Motor controller. 3. Branch circuit protection. 4. Branch disconnect

Fig. 3—Circuit diagram of across-the-line magnetic starter and maintained-contact pushbutton for providing low-voltage release.

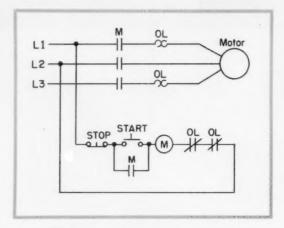


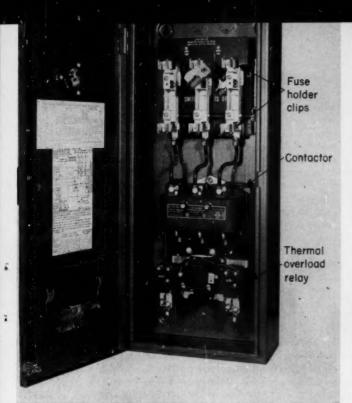
Fig. 4—Circuit diagram of across-the-line starter and momentary-contact pushbutton for providing low-voltage protection.

switch. A starter normally consists of a magnetic contactor and an overload relay, thus combining items 1 and 2. If a branch disconnect switch is added to a basic starter, the entire package is a combination starter with disconnect switch. If item 3 is also included, the result is a combination starter with fusible disconnect switch. Power circuits of these starters are shown schematically in Fig. 5. The control circuits, of course, are unaffected.

Starters with Circuit Breakers: A circuit breaker provides both branch circuit protection and branch circuit disconnect in a single package as shown in Fig. 6. If a predetermined, abnormal current develops in the circuit, the device will automatically trip without damaging itself and open the circuit. This nondestructive feature is its main advantage, for it can easily be reset without the nuisance of replacing a fuse.

Continuous current-carrying ratings of most circuit breakers used in combination starters range

START OL OL
STOP



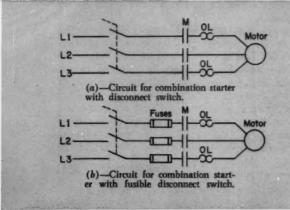


Fig. 5—Typical combination starter with fusible disconnect switch and circuit diagrams of the two basic combination starters.

from 10 to 800 amp. Interrupting capacities range from 7500 to 50,000 amp at 240 v and from 15,000 to 35,000 amp at 480 v. Circuit breakers are generally selected on the basis of a continuous current rating that is equal to 115 per cent of full-load motor current.

Ordinarily, each breaker contains two types of trip mechanisms. One is the thermal trip which has time-lag characteristics to provide protection against persistent overloads of comparatively small values. The other mechanism provides short-circuit protection through an instantaneous magnetic trip which opens the circuit instantly in event of high-value overcurrent. The magnetic trip device is usually adjustable. Thermal trips, however, are not adjustable. Thus, if the horsepower rating of

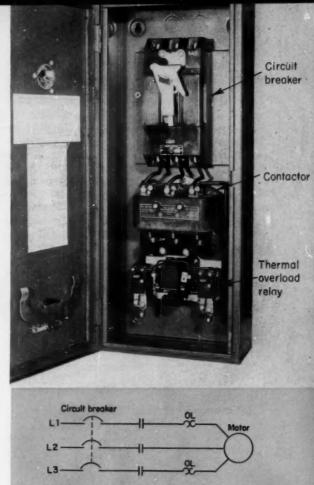


Fig. 6—Typical combination starter with circuit breaker and a diagram of its circuit application.

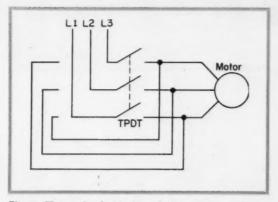


Fig. 7—Three-pole, double-throw knife switch used for reversing rotation of three-phase squirrel-cage motor.

the drive is changed, it will be necessary to change the trip unit, or, in some cases, to change the breaker frame size.

Three-Phase Reversing Starters: One of the basic characteristics of squirrel-cage motors is that the direction of rotation can be changed by reversing any two incoming power leads. On small motors this can be done with a three-pole, double-throw knife switch, Fig. 7. The third pole is used for disconnecting purposes only.

Reversing motor rotation can also be accomplished with a standard starter and a standard contactor which have proper electrical and mechanical interlocking, Fig. 8. The interlocking feature prevents both sets of contacts from being closed at the same time—even for an instant—so that there is no possibility of short circuits.

A system of double electrical interlocking is provided in the control circuit of Fig. 8 by:

- Normally open and normally closed circuits of pushbuttons for forward and reverse, respectively.
- Forward contactor

 Thermal overload interlock relays

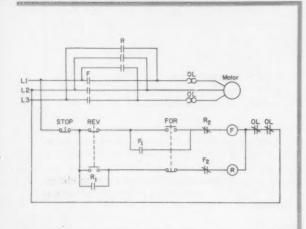


Fig. 8—Typical reversing starter with double electrical interlocking and diagram of its circuit application.

2. Normally closed auxiliary contacts, R2 and F2, on the

When the forward button is pressed, forward contactor coil F is energized through the stop button, upper contacts of the reverse button, and normally closed contact R_2^{\dagger} of the reversing contactor. The three main contacts of the forward contactor close to energize the motor. Coil F is kept energized, when the forward button is released, by holding-circuit contact F_1 .

If the reverse button in Fig. 8 is pushed, the forward circuit opens through the normally closed contacts of the reverse pushbutton. The forward contactor coil is de-energized, the forward contacts in the motor circuit open, auxiliary contact F1 in the forward holding circuit opens, and normally closed auxiliary contact F2 in the reverse circuit closes. The reversing circuit is thus completed through the momentarily closed lower contacts of the reverse button, the lower contacts of the forward button, and auxiliary contact F2. Reverse contactor coil R is energized, and reverse contacts in the motor circuit are closed. Auxiliary contact R2 opens in the forward circuit for added safety. The reverse contactor is kept energized by contact R1 in the holding circuit until either the forward button or stop button

In addition to electrical safeguards, usual practice is to provide a mechanical interlock which positively prevents one contactor from closing before the other is open. This interlock is indicated in the photo in Fig. 8. Also note that only one pair of overloads is used on a reversing starter.

ELECTRICAL BRAKING: A standard across-the-line reversing starter can also be used for quickly stopping an electric motor. With the motor running forward, the operator presses the reverse button. At

†Subscripts are used here to facilitate circuit tracing but normally are not used in commercial schematics.

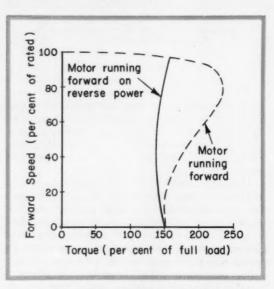


Fig. 9—Typical speed-torque curve for squirrel-cage motor during plugging.

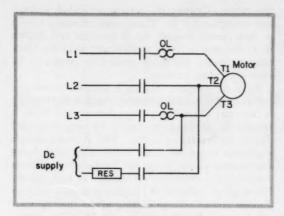


Fig. 10—Simple power circuit for dynamic braking of a squirrel-cage motor.

the instant the motor reaches zero speed, the operator shuts off the power with the *stop* button. This action is called "plug stopping."

Plug stopping is simple, inexpensive, and especially useful for such operations as lathe-turning, where it doesn't matter if the motor makes a few reverse rotations before power is cut. However, if the nature of the machine or job prohibits the possibility of any reverse rotations, a zero-speed switch can be mounted on the motor shaft to assure power cut-off at zero speed. Sometimes, torque developed during plugging may be too high and series primary resistance, in the form of "plugging resistors," is required to limit torque to a proper value. Fig. 9

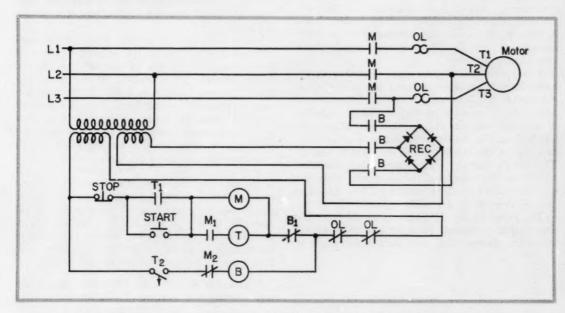


Fig. 11—Starter-control circuit for special application of dynamic braking to squirrel-cage motor. Main timer contact provides time delay upon de-energization of the timer coil.

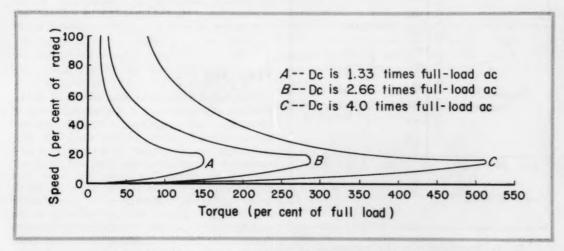


Fig. 12-Speed-torque curves for dynamic braking of typical squirrel-cage motor.

shows a typical speed-torque curve during plugging.

The main disadvantage of plug stopping is powerline disturbance, especially by larger drives. When this presents a problem, another practical method that is frequently used for quickly stopping a squirrel-cage motor is dc dynamic braking.

The general principle of dynamic braking is to make the drive motor function as a heavily loaded generator by cutting off ac power and applying dc across one stator winding. Principal requirements are a dc source capable of supplying about two or three times full-load current and a two-pole contactor to switch the dc in as soon as the main contactor cuts off ac power. Resistors are generally included in the dc power line to limit braking force. A timer drops out the dc contactor after the drive has come to rest. Fig. 10 shows how a simple power circuit could be wired.

A complete but slightly more complicated dynamic-braking schematic is shown in Fig. 11. When the start button is pressed, M contactor is energized and closes its contacts, starting the motor. Closing of auxiliary contact M_1 energizes the timer coil, which closes the timer's instantaneous auxiliary contact, T_1 , in the holding circuit for coils M and T. The timer's normally open delay contact closes instantly as the timer coil is energized. However, normally closed auxiliary contact M_2 has opened to prevent energizing of braking contactor B.

The motor in Fig. 11 continues to run until the stop button is pressed. Then, M contactor and the timer are de-energized, thus cutting ac power to

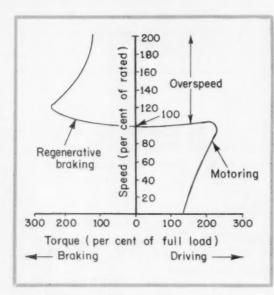


Fig. 13—Speed-torque curve for regenerative braking of typical squirrel-cage motor.

the motor. Contact M₂ returns to closed position and energizes coil B. The dynamic braking circuit is then closed through the B contacts and applies dc to the motor. Dc is applied only until the timer setting permits the delay contact to return to its normally open position,

Although dynamic braking is somewhat more expensive than the simple reversing action of plugging, it does not affect line current because the drive is completely disconnected from the power supply during the braking operation. Also, it produces high maximum torque with low losses, while high losses are incurred during plugging. Torque obtained from normal-slip motors falls off rapidly at high speeds. For a given value of dc, high-slip motors produce a much greater average braking torque than normal-slip motors. Rapid stops require high dc exciting current—dc equivalent to two or three times full-load current, or more, may be needed for extra-fast stopping. A typical dynamic-braking graph is shown in Fig. 12.

When induction motors are driven above synchronous speeds, they tend electrically to check or brake themselves through an inherent characteristic known as regenerative braking. Under these conditions, the motor acts as an induction generator. Retarding torque of a motor driven above synchronous speed is great, but losses are low. Braking from twice synchronous speed to synchronous speed results in losses about equal to starting losses.

A speed-torque curve for regenerative braking is shown in Fig. 13. The braking curve is similar to the motoring curve except that maximum torque is even greater during braking. In fact, maximum torque may be as much as 50 per cent greater but normally is only a few per cent higher. Regenerative braking is useful for limiting the speed of overhauling loads or for positive slowdown from high speed to low speed on multispeed motors.

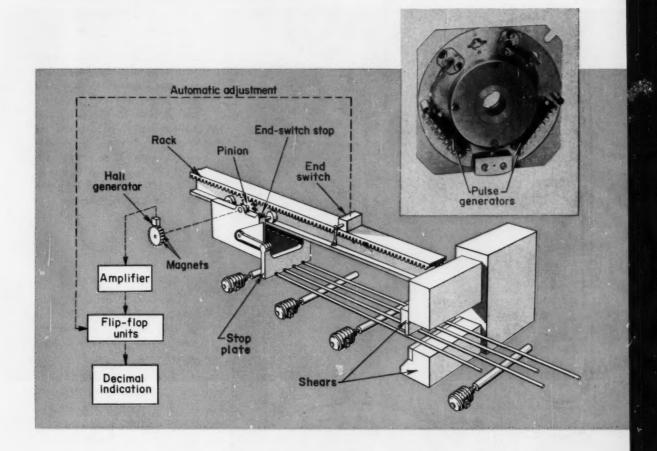
Next article in this series will cover reduced voltage starting and starting of part-winding motors.

REFERENCE

They say . . .

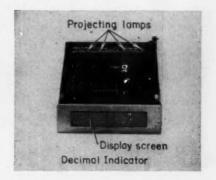
First, looked at from the point of view of the individual, it [engineering] is a wonderful means of education, which ranges from difficult mathematics to a practical knowledge of men and affairs. Secondly from the point of view of the country, a good engineer is a firstclass national asset and the money spent on his education is money well spent. And finally from the point of view of the world, we all know that there is building up a great demand for technical help and technical leadership in the underdeveloped countries." — Sir Patrick Linstead, Rector of the Imperial College of Science and Technology, London, England.

Magnetic Pickoff Reads Rack Progress Without Physical Contact

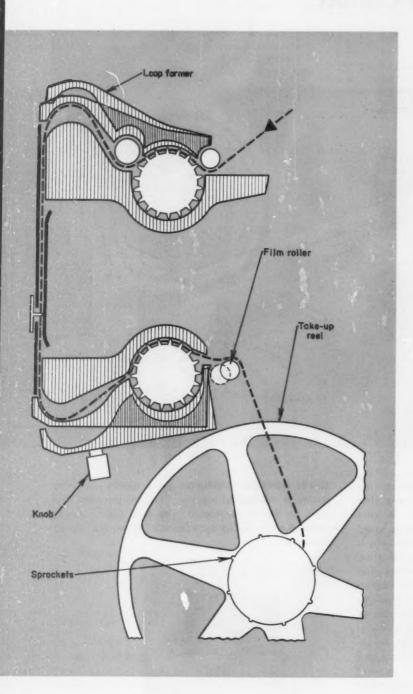


PULSE GENERATORS SCAN magnet heads in a revolving disc to indicate position of the stop plate on an industrial shearing installation. A small gear, mounted on the stop plate body, is turned by engagement with a rack as the stop plate is moved forward or back to position it for a cut. Mounted with the gear is a disc on whose outer circumference are mounted 80 permanent magnets with alternating north and south poles pointed radially outward. The pulse generators are so mounted that their signals are 90 degrees out of phase. The resulting signal train, gives an unambiguous indication not only of distance, but direction of travel. Cumulative error is cancelled each time the plate passes the end switch which closes a circuit to bring the counter to a precalculated distance mark.

BINARY SIGNAL IS TRANSLATED into a decimal number for display in the decimal indicator. Ten tiny projectors focus digits on the display screen. Stop-plate position sensing system was developed by Siemens & Halske AG, Munich, Germany.

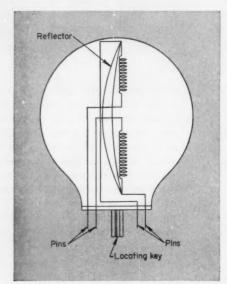


Film Tension Turns Off House Lights

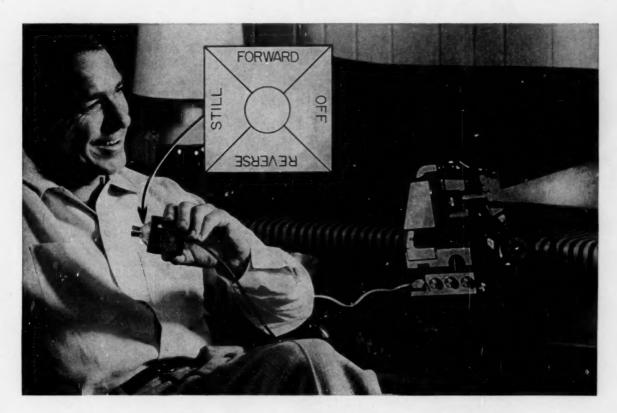


AUTOMATIC THREADING in a movie camera not only passes the film through the loop-forming path without the help of human hands, but catches it on the takeup reel, and trips a limit switch to shut-off house lights and start projection. Natural curl of the film as it leaves the projector starts it around the takeup reel. When a sprocket catches it, the tug deflects the film roller. A limit switch is tripped by the roller to shut off lights and turn on the projector lamp.

SPECIAL DUAL-FILAMENT projection lamp has high-low settings for large or small rooms. A knob on the control panel selects the lighting level desired.

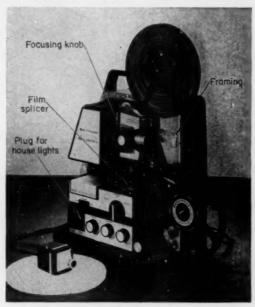


And Starts Projection Automatically

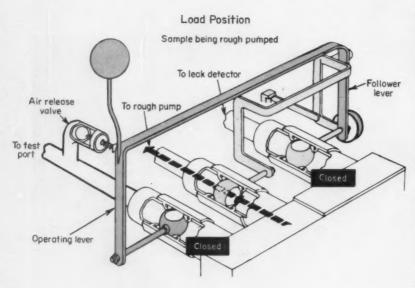


REMOTE CONTROL PERMITS operator to show stills, reverse, or shut-off projection from a comfortable spectator seat. Cord retracts on a spring reel, and remote control unit stores compactly in a cubbyhole in the bottom of the projector's business end. The blower operates on its own motor, therefore cooling is independent of whether film is stopped, advancing, or reversed. Air taken in at the blower is blown over the lamp and exits through vanes in the lamp housing.

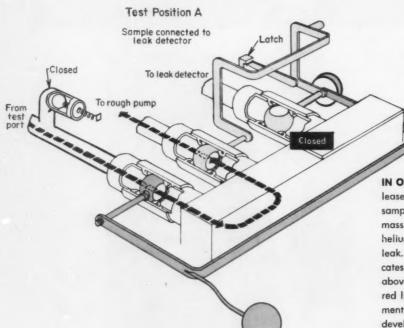
QUICK REPAIRS CAN BE MADE with the built-in splicer. Power cord retracts into the housing for compact storage. Dual/Lectric 8-mm movie projector with completely automatic threading is a product of Bell & Howell, Chicago, III.



Leak Test Table Uses Ball Valves



BALL VALVES ELIMINATE complex linkages and multiplicity of solenoids used with plungertype valves in leak test tables. A handle on the operating lever puts the entire testing sequence into operation. Moving the operating lever closes the airrelease valve and opens a testport valve. After the sample is exhausted by the rough pump, a pressure signal actuates a small solenoid to release the latch holding the follower link. Simultaneously, the pump valve is closed and the detector valve opened. In case of breakage or accidental removal of the specimen, rapid pressure rise in the detector triggers a solenoid to release the operating link and allow all valves to return to load position, thus protecting the sensitive detector.



IN OPERATION, helium gas is released around the evacuated sample. Leak detector is a mass spectrometer which detects helium that enters through the leak. Output instrument indicates size of leak and, if it is above a predetermined level, a red light will flash on the instrument panel. Leak test table was developed by General Electric, Schenectady, New York.

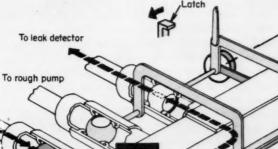


Spring Assembly

Test Position B

Sample connected to leak detector

From test port



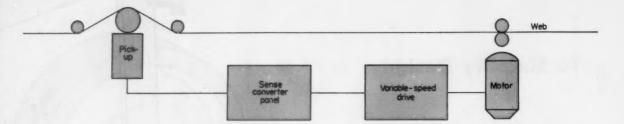
Operating lever latch

LEVER SPRINGS ARE HOUSED in one unit. Spring for the follower unit is anchored to the same housing as the spring for the operating lever. Emergency return of this linkage is very fast, since torque of the two springs do not oppose each other.





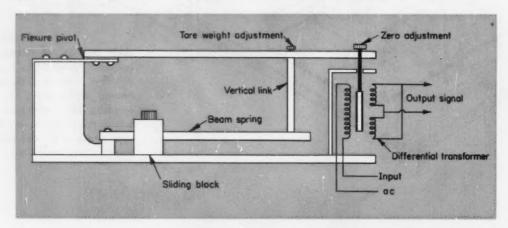
January 5, 1961



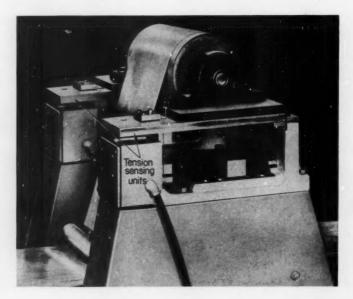
Tension Regulator Range Is Adjusted By Changing Effective Spring Rate

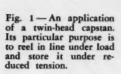
SCALE OF READING IS CHANGED in a tension regulating system by adjusting the effective length of a beam spring with a sliding block. Direct feedback of signals from web-tension sensor to the electric-motor drive system gives immediate response to sensed tension ir-

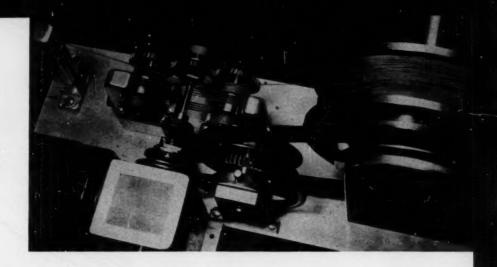
regularity. The drive consists of one or more adjustable-speed dc motors. Tension is sensed by electronically read spring scales. Deflection of scale platform moves a core in the differential transformer. The resulting output indicates direction of deflection by phase of its signal.



WEB TRANSMITS tension information for its section directly to the transducer making unnecessary any form of storage loop. Tare-weight adjustment and zero adjustment are set to center the platform in the deflection range and provide "no output" signal at optimum webtension conditions. The force transducer is produced by Hydro-Pneu-Tronics, Cleveland. The tension-regulating drive system in which it is used is a product of Reliance Electric and Engineering Co., Cleveland.







Design details and working equations for

A TWIN-HEAD CAPSTAN

 a classic tension multiplier redesigned to assure continuous, jerk-free take-up of a line

J. H. HENSON

Systems Development Specialist Defense Research Laboratory University of Texas Austin, Texas

THE traditional shape of the capstan has gone almost unaltered for centuries. However, this very shape results in the capstan's greatest disadvantage. The concave face, though effective in preventing a line from working itself off the capstan, still allows some axial crawling due to a helical effect. Periodically, the line suddenly slides back to the drum center, causing an intermittent jerk.

A modified capstan drive, which eliminates this condition and insures a smooth take-up, features a pair of grooved drive pulleys, instead of the traditional single concave driver, Fig. 1.

The arrangement of the drive pulleys and takeup reel is shown in Fig. 2. The two pulleys, with the take-up line threaded as shown, are driven in the same direction and at the same speed. The slid-

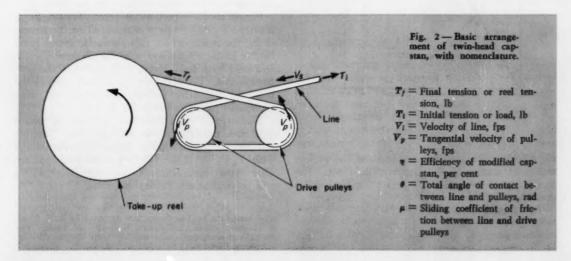


Fig. 3—Right—Efficiency of capstan drive.

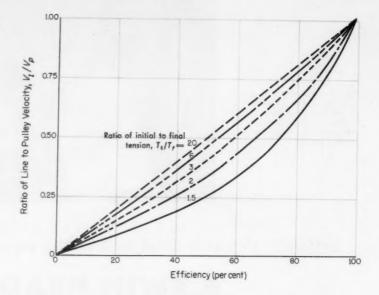
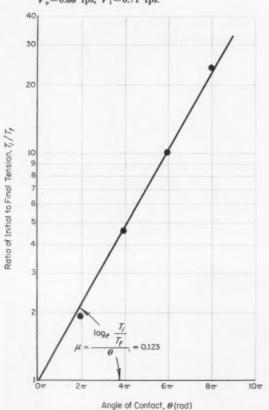


Fig. 4 — Below — Measured values of T_t/T_t , as a function of θ , where $T_t=25$ lb, $V_p=0.88$ fps, $V_1=0.71$ fps.



ing-friction force between the line and the pulleys results in a ratio of T_i/T_f greater than one. The line is stored at tension T_f , and V_i is always less than V_a .

The amplification ratio is

$$\frac{T_i}{T_I} = e^{at} \tag{1}$$

For a given coefficient of friction this ratio can be changed by simply varying the angle of contact.

If mechanical parts are considered 100 per cent efficient, the efficiency of the modified capstan, including the take-up force, is given by

$$\eta = \frac{100 \ T_i \ V_l}{(T_i - T_f) \ V_p + T_f \ V_i} \tag{2}$$

It is important to keep ratio V_1/V_p near unity. If V_1 is zero, all the energy is dissipated in the form of frictional heating of the pulleys. A plot of Equation 2 is given in Fig. 3.

In the mechanism shown in Fig. 1 the drive pulleys are hardened, polished steel. The take-up reel is driven through an appropriate gear ratio by the same motor that drives the pulleys. Although this arrangement produces a variation in V_1/V_p as the effective diameter of the take-up reel changes, the variation is small enough to be tolerated in this case. A slip clutch is provided in the take-up reel drive to prevent breakage of the line if T_4 becomes too high. During line feed-out, the drive pulleys and take-up reel are disconnected from the motor.

Fig. 4 shows experimental points plotted for a constant V_l/V_p . Angle θ was varied in increments of 2π , the maximum for this particular device being 8π . A 25-lb weight was used for T_i , and T_f was measured by a small spring scale placed in the lowtension side. The coefficient of friction between the line and the drive pulleys was determined from Equation 1 rearranged as in Fig. 4.

The capstan drive described here has performed quite well through several half-hour tests. Line life was checked by making 25 passes over the pulleys with $V_l/V_p = 0.75$. No line wear was apparent after these tests, although lower values of V_l/V_p will no doubt cause more rapid wear.

ACKNOWLEDGEMENT

The basic idea for this device was suggested by S. E. Smith of Defense Research Laboratory, University of Texas. The device was developed under contract with Wright Air Development Division.

Rotor blade of three different metals is bonded together with heat-cured adhesive film. Bonded construction improves vibration resistance over riveted blade and increases blade life.

Stainless steel Aluminum extrusions Aluminum Adhesives, Coatings and Sealers Div.

High-Strength Structural Adhesives

. . . properties of some of today's major structural-bonding materials

MONG the general - purpose structural adhesives, the elastomeric phenolics and modified epoxies have assumed a dominant position. Although both are high-strength adhesives, properties and application methods of each type differ and must be matched to the job requirements.

Among the most important selection considerations are the adhesive-strength requirements (peel, shear, tensile, and cleavage) for an application. The adhesive must also have the ability to withstand weathering, moisture, chemicals, temperature differences, or fatigue as required by the application. It must be capable of adequately wetting the surfaces to be bonded, in addition to having the required adhesion to those surfaces.

The joint should be designed to take full advantage of the adhesive's properties. Adhesives seldom display the best properties when substituted directly for other fastenings.

Finally, available facilities to produce bonds of

desired strength and performance levels must be considered.

Elastomeric-Phenolic Adhesives

Thermosetting films of the elastomeric-phenolic type are made in continuous form in thicknesses from 0.003 to 0.010 in. The film is rolled on a nonadhering liner and remains stable for long periods when properly stored.

Film adhesives provide uniform adhesive thickness throughout the joint and controlled confinement of adhesive to the immediate bonding area. Application and curing procedures are simple, since film adhesives do not contain solvents.

Film-type adhesives offer the best compromise of shear strength, peel strength, shock, and fatigue resistance. They adhere well to metals and plastics and offer flexibility, impact strength, and vibration absorption.

E. F. HESS

Product Manager

St. Paul, Minn.

Minnesota Mining & Mfg. Co.



Some film adhesives can be used for high-strength bonding applications at temperatures as $1\,\mathrm{o}\,\mathrm{w}$ as $-80\,\mathrm{F}$; others can withstand moderate stress at $600\,\mathrm{F}$ for short periods.

Thermosetting adhesives require both heat and pressure to produce the bond. Pressure is needed to bring the metal parts into contact and to contain volatile byproducts given off during the curing re-

action. If pressure is not maintained during the cure, the vapors cause a porous bond.

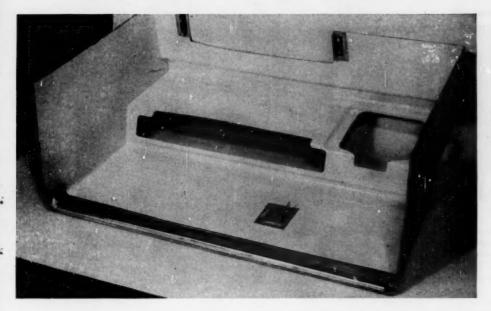
Bonding pressure should be applied uniformly before the temperature of the bond line reaches 180 F. This pressure causes the adhesive to flow, to wet the surfaces, and to fill small mismatched areas. A bonding pressure of 25 to 150 psi is required, depending on the rate of heat input to the bond line,

Table 1—Properties of Elastomeric-Phenolic Film Adhesives

Adhesive*		-67 F	at Vari		ength+ (p		Peel Strength at 75 F8	Remarks		
rt. Mil	ment A C.	-61 1	75 F	190 L	300 F	400 F	(lb/in. of width)	Benuras		
	A	3000	3040	1750	700	470	95-100	Exceeds MIL-A-5090D, Type 1 requirements. Available in 3, 6 and 10-mil thicknesses.		
	В	4000	4180	2200	1800	620	75-80	Exceeds MIL-A-5090D requirements. Low-pressur bonds are also possible.		
	O	2850	3800	2800	2100	1050	55-60	Exceeds MIL-A-5090D, Type 2 requirements. Available in 3 and 10-mil thicknesses.		
	D	4500	3200	2000	900	510	105-110	Exceeds MIL-A-5090D, Type 1 requirements. Ha excellent flexibility and resistance to shock. Available in 3 and 10-mil thicknesses.		

Table 2—Properties of One-Part Heat-Curing Modified-Epoxy Adhesives

Adhesive*							Strength 75 Fg of width)	Remarks		
E	3240	5500	5100	700	200		8-10	General-purpose adhesive. Meets MIL-A-8623A, Type III requirements.		
F	2725	2935	3100	2980	300		3-5	Exceeds MIL-A-5090D, Type 2 requirements.		
G.	2385	2475	3000	2275	300		3-5	Paste form of adhesive F.		



Metal clips for attachments and mountings are bonded to inside of polyester fiberglass cover for Thermo-fax copying machine with twopart RT-curing modified epoxy adhesive.

Advantages of Adhesive Joints

- Because adhesives form continuous bonds, stress loads are distributed over the entire joined area.
- Sealing and bonding are done in a single operation.
- Fatigue stress in metal parts is reduced because the flexible bond damps or absorbs vibration.
- Adhesives act as continuous barriers between dissimilar metals.
- Adhesive-bonded joints have no gaps, bulges, external projections, or surface mars.
- Because drilling or countersinking of parts is unnecessary, structural soundness is not impaired.

Table 3—Curing Cycles for One-Part Modified-Epoxy Adhesives

Temperature of Bond Line (F)	Curing Time (min)
350	40-60
400	15-20
456	6-12
500	1-2

composition of the adhesive, and thickness of the metals being joined.

The gradual application of heat produces many changes in elastomeric-phenolic film adhesives: 1. Between 160 and 180 F the surface becomes tacky, and the film can be heat-tacked in place on the adherend prior to bonding. 2. Between 180 and 210 F the adhesive becomes thermoplastic and wets the adherend. 3. Between 220 and 250 F the cross-linking or polymerization reaction begins. 4. At 300 F polymerization is 90 per cent complete. 5. Between 325 and 350 F polymerization is completed and toughness is developed.

For adhesives A through D, Table 1, maximum strength is obtained with a 1-hr cure at 350 F under 100 to 150 psi pressure. However, bond shear strength in excess of 2500 psi can be achieved with a cure time as low as 2 to 3 minutes at 400 to 450 F.

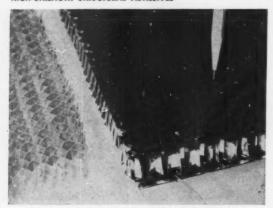
Modified-Epoxy Adhesives

Available in a two-part, room-temperature-curing type (RT), and a one-part heat-curing type, modified-epoxy adhesives offer high strength, resistance

Table 4—Properties of Two-Part RT-Curing Modified-Epoxy Adhesives

Adhenive*			Strengtht (p Temperatures 180 F		Peel Strength at 75 FW (lb/in. of width)	Work Life at 73.5 F (min)	Remarks
H	1500	2800	700	-	3-5	15	General-purpose adhesive. Syrupy consistency. Bonds glass, metals, and ceramics.
. 1	900	1600	2400	-	3-5	120	General-purpose adhesive, Syrupy consis- tency. Bonds glass, metals, and ceramics.
3	1400	2300	800	150	4-5	45	Nonsagging mastic-type adhesive. Can be sanded, machined, or painted.
K	1500	3200	800	200	4-5	45	Has excellent shock resistance. Two parts are of different colors for easy visual determination of mix.
I.	1400	3000	800	150	4-5	45	General-purpose aluminum-filled adhesive.

*Designations of adhesives are arbitrary. †Tested per MIL-A-5000D specification, †Climbing-drum peel test, per MIL-A-25463 specification.



Adhesive-bonded honeycomb structure with one facing removed, right, illustrates self-filleting properties of one-part modified-epoxy adhesive. Uncoated honeycomb core is shown at left.

to creep under constant stress, and exceptional adhesion to most surfaces.

Modified-epoxy adhesives are self-filleting and are used in honeycomb-sandwich construction. Because no gaseous byproducts are given off during the curing cycle, they are excellent choices for bonding impervious surfaces. Since the consistency of modified-epoxy adhesives is about that of paste, they have fair void-filling properties and can be used for structural joining of loosely fitting parts. These adhesives require only contact pressure during the cure.

One-Component Adhesives: Single-component modified epoxy resin adhesives, Table 2, contain a latent hardener that is activated by the temperature of the curing cycle. This type of adhesive has an unlimited working life, unlike the two-component type. Although the recommended curing cycle is 1 hr at 350 F, exposure to higher temperatures can reduce curing time considerably, Table 3.

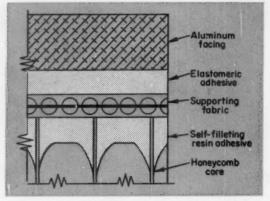
Two-Component Adhesives: Two-component modified epoxy adhesives, Table 4, consist of a base resin and a separate liquid catalyst or curing agent. The two materials are mixed immediately prior to their use. As soon as the components are mixed, the cur-

Table 5—Environmental Resistance of Adhesives*

the same of the sa			
Environment	Adhesive	Resistance	
Tap Water, 80 F	A through G H through L	Excellent Fair	
Salt Spray, 20 per cent, 105 F	A through G H through L	Excellent	
Hydraulic Oil	A through L	Excellent	
Aromatic Fuels	A through L	Excellent	
Dry Heat, 192 hr at 300 F	A through G H, I J through L	Excellent Poor Good	

^{*}Arbitrary designations of adhesives are the same as those used in Tables 1, 2, and 4. Tests are in accordance with MIL-A-5090D, Type 2 specifications.

†Excellent = over 90 per cent of original strength; Good = 75-90 per cent; Fair = 50-75 per cent; Poor = under 50 per cent.



Section through a bonded honeycomb-sandwich panel shows how a composite film provides a sturdy bond to the core and facing. This type of film affords the best combination of peel and beam strength for honeycomb-sandwich construction.

ing reaction begins, slowly at first, then more rapidly. Heat accelerates the cure, and since the chemical reaction is exothermic (produces heat), the temperature must be kept relatively low by limiting the size of the mixed batch, by cooling it artificially, or by spreading it on a flat surface to dissipate the heat. These methods prolong the working life of the mixture considerably.

Two-component modified-epoxy systems cure at room temperature in about 7 days. They are used for bonding in applications where facilities for heat or pressure are not available. Curing can be accelerated, however, by heating the assembly in an oven, under infrared lamps, or with dielectric or induction heating apparatus.

Composite Film Adhesives

Supported composite adhesive films have a high-strength, peel-resistant adhesive film on one surface and a self-filleting adhesive film on the other. These films provide high peel strength and beam-shear strength for applications of honeycomb-sandwich construction. The peel-resistant adhesive (elastomeric phenolic) bonds to the facing, and the self-filleting adhesive (modified epoxy) bonds to the core of the honeycomb-sandwich panel. This arrangement provides high strength properties at service temperatures from -70 to 250 F.

Aluminum honeycomb-sandwich panels of this construction have beam-flexure strengths of 1580, 1530, and 1385 psi at temperatures of -67, +80, and +180 F respectively when tested per MIL-C-7438B specification. Peel strengths (climbing-drum method) of these panels are 18, 24, and 21 lb per in. of width at the same test temperatures.

Because composite film adhesives do not require priming of the honeycomb-sandwich core, weight of finished panels is kept to a minimum. For the same reason, fabrication costs of this type of construction are attractive.

Charts for determining

Hole-Position Tolerances

in fastener assemblies

DONALD J. BUCHMAN and FRANK H. SMITH

Large Jet Engine Dept. Flight Propulsion Div. General Electric Co. Evendale, Ohio University of Michigan Ann Arbor, Mich.

RUE-POSITION dimensioning provides a simple, direct method for controlling the location of fastener clearance holes to assure interchangeability of parts. In this system of dimensioning, the theoretically exact location or true position of the hole center is established from a datum and a tolerance zone is assigned to define the permissible limits of position variation. This tolerance specification is governed by hole size, fastener size, and type of fastener assembly. Basic principles of the true-position system of dimensioning and tolerancing are detailed in American Standard ASA Y14.5, SAE Aero-Space Drafting Manual, and government standard MIL-STD-8.

This article presents two charts, Fig. 1 and 2, for quickly determining true-position tolerances for drilled clearance holes in interchangeable parts which are to be assembled with standard fasteners. The charts are based on preferred drill sizes and hole-size tolerances given in Section Y1.01 of the SAE Aero-Space Drafting Manual. These tolerances are generally accepted as good practice. Range of the charts has been selected to cover preferred clearance hole diameters and corresponding position tolerances for the most widely used screw-thread sizes, from No. 8 (0.164) through \(^{5}\)8 (0.625) in.

Chart Construction: The fixed-fastener chart, Fig. 1, covers the use of studs, cap screws, machine screws, and similar fastening elements in assemblies where the fastener is fixed with respect to one of the parts being fastened. This chart solves the relationship

$$Z = \frac{H_{min} - F}{4}$$

where Z= true-position tolerance, expressed as a radius, for all holes located in mating parts; $H_{\min}=$ minimum clearance-hole diameter; F= maximum diameter of fastener.

The floating fastener chart, Fig. 2, covers throughbolt and similar assemblies where all of the parts being fastened have clearance holes. This chart solves the relationship

$$Z = \frac{H_{min} - F}{2}$$

Inclined drill-size lines on the charts correspond to maximum material condition (minimum hole size) for the preferred drill sizes. Drilled-hole tolerances for these drill sizes are given in Table 1. If required,

Table 1-Drilled-Hole Tolerances

Nominal Drill Size (in.)	Hole-Sine Tolerand (in.)		
0.0135 (No. 80) - 0.185 (No. 13)	+0.003		
0.1875 - 0.246 (D)	+ 0.004		
0.250 - 0.750	-0.002 +0.005		
	-0.002		

other clearance-hole lines can be added to the chart by interpolation, based on these conditions.

Value of the position tolerance is read directly from the charts at the intersection of the drill-size and the fastener-size lines. These tolerance values are expressed in terms of a radius of true position at maximum material condition.

Practical Example: A ½-in. cap screw is to be used to assemble a part with a clearance hole to another part with a tapped hole. The clearance hole will be produced with a standard 0.2720 in. (Size I) drill. Find the true-position tolerance.

In the fixed-fastener chart, Fig. 1, find the intersection of the 0.2720-in. drill-size line with the 0.250-in. fastener-size line. Corresponding position tolerance is 0.005 in. or, in more exact form, 0.005-in. radius of true position at maximum material condition. This tolerance applies to the location of both tapped and clearance holes.

Position Tolerance, Z(in)

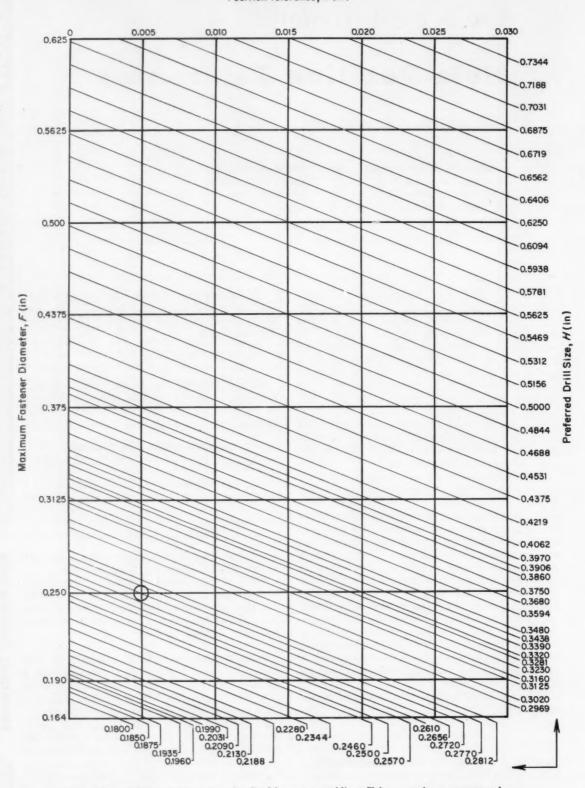


Fig. 1—True-position tolerance chart for fixed-fastener assemblies. Tolerance values are expressed as a radius of true position at maximum material condition. Circled point is solution for example.

Position Tolerance, Z (in.)

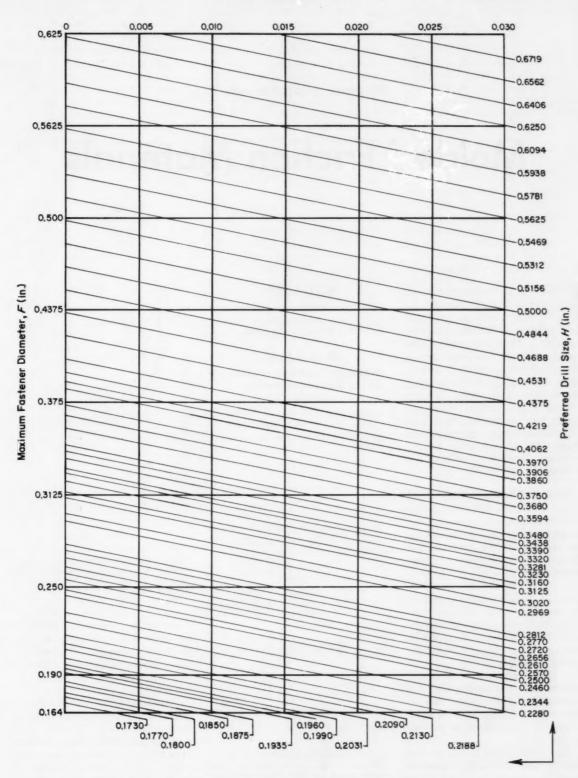


Fig. 2—True-position tolerance chart for floating-fastener assemblies. Tolerance values are expressed as a radius of true position at maximum material condition.

Dynamic characteristics of

Molded Friction Materials

I N the design of mechanisms which use molded friction materials, little more than a nominal value for the coefficient of friction is usually There are many cases available. where variation of the coefficient of friction with load, velocity, temperature, and surface conditions must be known. This article presents the results of a study which was undertaken to furnish design data for molded friction materials, and to provide an explanation for the frictional phenomena reflected by these data.

Friction Theories: The classic theory of friction states that the coefficient of friction between two materials is independent of the normal load between the two materials, and the area of contact between the two materials.

A second theory of friction attempts to explain frictional phenomena on a molecular adhesion basis. Here, the frictional force is attributed to the interaction of molecular forces at the intersurfaces of the two mating materials.

A third explanation of frictional phenomena is the asperity theory of friction. Here it is supposed that the frictional force arises from an interlocking of microscopic surface asperities,

The presence of contaminating films between the mating surfaces is generally accepted in the field. These films may be due to dirt between

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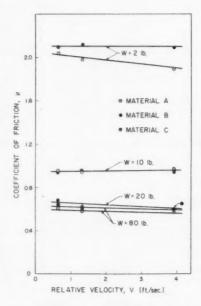


Fig. 1—Effect of relative velocity on coefficient of friction for three materials under typical loading. Data are for test specimens rubbing on uncleaned steel drum.

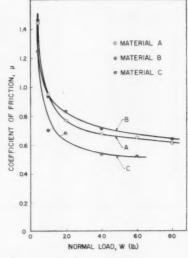


Fig. 2—Effect of normal load on coefficient of friction for three materials. Data are for test specimens rubbing on uncleaned steel drum at 0.655 fps.

the mating surfaces, lubricants placed there intentionally or unintentionally, atmospheric conditions, and, most important, deposits of the softer material on the harder.

Results and Conclusions: Results of the present investigation are given in Fig. 1, 2, and 3.

Data presented were obtained from tests of three separate materials, identified as A, B, and C, each made by a different manufacturer. All these materials had roughly the same composition: Approximately 50 per cent (by volume) asbestos fiber, 25 per cent resin, and 25 per cent friction modifiers. For each material, data were taken over a loading range of from 2 to 80 lb and for drum speeds of 50, 100, and 300 rpm. At each operating condition, a minimum of ten separate readings was recorded and the average value used. All materials had an apparent bearing surface of ½ by 5% in., where the latter dimension is measured along the circumference of the drum.

Conclusions are:

1. The coefficient of friction of the molded friction materials tested decreases with increasing load, W. It is thus apparent that these materials do not conform to the classic law.

The results could be explained by a nonlinear relationship between the

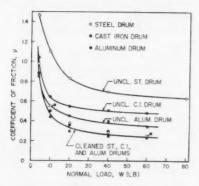


Fig. 3—Effect of normal load on coefficient of friction for specimens of the same material rubbing on uncleaned and cleaned drums of steel, cast iron, and aluminum at 0.655 fps.

applied load W and the projected real frontal area of contact A_f between mating asperities. This would assume a relationship of A_f versus W. Then an increase in W at light loads would cause a larger increase in A_f than a corresponding increase in W at heavy loads. Such a possibility is entirely plausible and has attracted some current support.

2. The value of the coefficient of friction depends upon the presence of a deposited intersurface. When a relative velocity exists between the friction material and the mating metallic surface, a film is deposited by the friction material on the metal that increases the frictional capacity. One possible explanation of this

film effect is based on the molecular adhesion theory of friction. This assumes the adhesion forces between the friction material and its deposited film to be greater than the adhesion forces between the friction material and the clean metal.

However, this film phenomenon also could be explained on the basis of the ploughing or asperity theories of friction. If it is indeed the frontal area of contact A_f between the asperities of the friction material and the metal that cause the frictional force, then it is possible that small particles of the frictional material are deposited in the microscopic crevices of the metal, thus increasing A_f .

- 3. The coefficient of friction is essentially independent of sliding velocity. There were some indications that μ might decrease slightly with increasing velocity, but this variation of μ is negligible as compared to the variation of μ with W. Further, the scatter of the data prevents any firm conclusions regarding the dependence of μ upon V.
- 4. The coefficient of friction is independent of temperatures below 500 F. At temperatures above 500 F, the value of μ decreases, with a corresponding drop in temperature, and then slowly builds up again. This suggests the possibility that the high temperatures affect μ by altering the surface film. Apparently the film breaks down at high temperatures.
- 5. The coefficient of friction is independent of apparent normal area of contact. The only exception noted is a decrease in μ when the specimen width (perpendicular to the direction of rubbing) decreases below a certain minimum. This is probably due to edge effects on the film.
- 6. The coefficient of friction is independent of the surface finish on the mating metal. This is true as long as the surface is at all scratched. Initial run-in of the friction material on a smooth (as machined) drum indicates that the friction material has the ability of almost immediately galling, or scratching, the metal surface and that the coefficient of friction rises to a stable value once this galling has occurred.

Subsequent increases in surface roughness to extreme values do not affect μ . The possibility exists that the surface film must have at least a slightly marred metal surface on which to anchor.

- 7. Initially, before run-in, the coefficient of friction is independent of the metal against which it rubs. This may be seen from Fig. 3 in which three different metals all yield the same values for μ when the metal is clean.
- 8. After run-in, the type of metal does have a marked effect on the coefficient of friction. From Fig. 3 it may be seen that the harder the metal, the higher the value of μ . This suggests the possibility that the harder metals offer more support for the deposited surface film.

In the application of molded friction materials, the mating metal is usually unclean. Therefore, this effect must be kept in mind in choosing the mating metal parts of the friction device.

iriction device.

9. The exact nature of the deposited intersurface film and its effect on the frictional phenomenon is unknown. It appears that this would be a promising field of research if the film were to be studied microscopically. At the same time, the dependence of the microscopic A_f upon W could be investigated.

ASME Paper No. 60-WA-35, "The Dynamic Frictional Characteristics of Molded Friction Materials," presented at the Winter Annual Meeting, New York, Nov.-Dec., 1960, 8 pp.

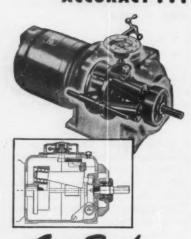
Magnetic Properties Of Malleable Irons

W. K. BOCK, Director of Research, National Malleable and Steel Castings Co., Cleveland, Ohio

T. D. HUTCHINSON, Supervisor of Physical Metallurgy, Malleoble Research and Development Foundation, Dayton, Ohio

THERE is a need for cast magnetic alloys and only ferritic malleable iron and dynamo steel are available. Dynamo steel is difficult to cast and its machinability is poor. Malleable in all types, on the other hand, is available in large quantity, and its castability and machinability are two of its strong

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GRAHAM TRANSMISSIONS, INC.

DESIGN ABSTRACTS

Table 1-Magnetic Properties of Malleable Irons

	Ferritie	Pearlitic	Martensitie	Dynamo stee
Brinell range		163-241	179-269	
Saturation (gauss)	18000	<18000	<18000	21400
Maximum permeability	3100	430	170	6000
Magnetizing force for s max (oersted)	11	15	30.5	
Hysteresis loss (erg/cycle/cm3)*	6400	10000-16500	15000-26000	
Retentivity (gauss)*	5000	6500-8500	6900-8800	8500
Coercive force* (oersted)	2.3	7.5-15	11-22	5.0
Steinmetz constant	0.0025	0.0043-0.0072	0.0059-0.0102	
Electrical resistivity (microhm-in,)	14.14	15.94	16.26	

*At maximum induction, B=10 gauss

points.

Ferritic or standard malleable iron has an ideal microstructure and composition for a machinable soft, magnetic alloy, since it consists of graphite in an iron matrix which contains practically no combined carbon and does contain 1.0 to 1.5 per cent silicon. Compared to pure iron or silicon iron, malleable has a lower saturation and lower maximum permeability. It has close to the same hysteresis characteristics and higher resistivity; therefore, lower eddy current loss.

White iron is the base from which ferritic malleable is made, and when the white iron is given different heat-treatment, it is converted to either pearlitic or martensitic malleable. Thus, from a single starting alloy, the malleable foundry produces a family of products which cover a wide range of hardness and strengths.

The pearlitic and martensitic malleables bear the same relation to ferritic malleable that steels do to iron. They are, in fact, graphitic steels.

Although steels, particularly the higher carbon grades, are not generally considered for soft, magnetic work, some designers have been tempted by the inherent advantages the magnetic properties were determined to make such a compromise possible. The essential magnetic properties and electrical resistivity are given in Table 1. For comparison, magnetic data on dynamo steel are included in the table.

The Brinell ranges shown in Table I are those which are generally available in pearlitic and in martensitic malleable irons. The magnetic data in some cases were extrapolated to cover the full Brinell range.

To show what sacrifice of magnetic properties would be made for a gain in hardness, Table 2 was prepared. It is possible in some cases to obtain a given hardness either in the martensitic malleable or pearlitic malleable. As shown in Table 2, the magnetic properties in such a case are better if a pearlitic malleable is specified.

As might be expected, the pearlitic and martensitic malleables investigated here have behaved like unalloyed steel. The response to magnetizing force and maximum permeability followed exactly the relations in steel of different carbon contents. The magnetizing force for maximum permeability seems to be influenced by microstructure, as in the case of steels.

Table 2-Malleable Irons for 10 Kilogauss Induction

	Ferritic	Pearlitie	Marte	ensitic
Brinell	109	212	212	260
Magnetizing force (oersted)	12	30	35	35
Permeability	800	340	160	160
Electrical resistivity (microhm-in.)	14.14	15.94	16.21	16.21
Hysteresis loss (erg/cycle/cm ²)	6	14	18.5	24
Coercive force (oersted)	2	12.5	15.5	21
Retentivity (gauss)	5000	7700	7700	9000

of mallcables to use the stronger types though the magnetic properties are not as good as the properties of ferritic malleable. Data on ASME Paper No. 60-WA-218, "Magnetic Properties of Malleable Irons," presented at the Winter Annual Meeting, New York, Nov., Dec., 1960, 9 pp.

mechanical

A German-English Glossary Of Kinematics

R. S. Hartenberg, professor of mechanical engineering, Northwestern University, and T. P. Goodman, kinematics engineer, General Engineering Laboratory, General Electric Co.

Some of the most frequently used terms in kinematics in the growing literature of German origin. This glossary presents a special vocabulary not found in dictionaries. However, some words that properly belong to a general vocabulary have been included. The glossary may be considered only as a supplement to one or more standard dictionaries. No grammatical problems are discussed.

ASME Paper No. 60-WA-48, "Kinematics—A German-English Glossary," presented at the Winter Annual Meeting, New York, Nov.-Dec., 1960, 5 pp.

processes

Progress in Vacuum Die Casting

Hiram K. Barton, president, Hiram Barton Associates

Recent progress made possible mainly by improved vacuum systems. Vacuum systems can be classified according to whether the die is evacuated after closure, or the vacuum is pulled before the die comes up and closes. With methods of the first kind, it is difficult to maintain a standard level of vacuum. The point of importance is not the actual amount of air and gas remaining to be trapped in the casting, but the effect of this variable factor on metal flow and, hence, upon the surface finish and quality standard of the resulting casting. These variables are eliminated when the vacuum is pulled before the die closes. Occluded gases boil off, but they can escape before the die closes. The degree of evacuation achieved is exactly the same at each cycle, giving virtually complete uniformity of metal flow if the casting temperature is held constant. This is the most important functional advantage of the system, and the basis for technological advance into the field of very large, very



RIVNUTS* streamline tank design; eliminate damage to product

This oil reservoir, fabricated by Stolper Steel Corporation, Menomonee Falls, Wisconsin, for a husky new Allis-Chalmers tractor-shovel, requires removable cover plates. This is accomplished with flush-mounted RIVNUTS and threaded bolts.

With RIVNUTS, all possible damage is eliminated, since the RIVNUTS project inside the tank. Installation is simple: holes drilled and countersunk, RIVNUTS upset with a heading tool. Flush installation permits obtaining a liquid-tight joint without grinding.

RIVNUTS are the only one-piece blind rivets with internal threads. If you'd like recommendations on a specific fastening problem, please send a print of your part. For descriptive bulletin, see Sweet's Product Design File, or write Dept.MD-1, B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Akron, Ohio.

B.F. Goodrich Rivnuts



thin die castings.

SDCE Paper No. 25, "Vacuum Die Casting—A Resume of Progress to Date," presented at the First National Die Casting Exposition & Congress, Detroit, Nov. 1960, 12 pp.

management

Management of Electronic Parts Specifications

E. J. Nucci, reliability co-ordinator, Office of Electronics, Office of Deputy Director of Research and Engineering, Department of Defense

Establishment and effective management of an engineering standardization program for electronic parts. Subjects covered include:

- Specification of reliability of parts and tubes in terms of failure rate as a function of time, appropriate test procedures, and plans for determining compliance with the level specified.
- Methods used in preparation and coordination of parts and tubes specifications.
- Qualification approval testing requirements and procedures.
- Adequacy of test requirements with respect to reliability requirements and quality control procedures.
- Program for exchange of technical characteristics and test data on parts and tubes.
- Methodology for development and dissemination of design guides or parts application data, including failure rate data as a function of circuit application severity level and environment.

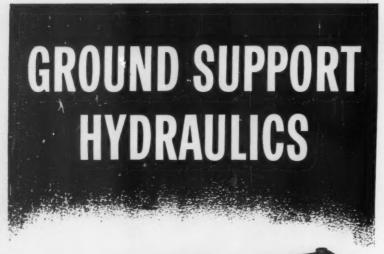
ASA paper, "Briefing on Report of Ad Hoc Study on Electronic Parts Specifications Management for Reliability," presented at the Eleventh National Conference on Standards, New York, Oct., 1960, 15 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

ASA-American Standards Association, 70 East 45th St., New York 17, N. Y.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 50 cents to members. one dollar eo nonmembers.

SDCE—The Society of Die Casting Engineers, 19382 James Couzens Highway, Detroit 35, Mich.





H-P-M 4-Way Valve; 3000 psi, 450 gpm, pilot operated, flange connections.





H-P-M 4" Angle Check Valve; 3000 psi, flange connections.

H-P-M 3-Way Valve; 3000 psi, 350 gpm, pilot operated, flange connections.

H-P-M valves, such as those illustrated, are used on Titan ground support installations. Moving large volumes of oil at high pressures for today's missile installations parallels H-P-M's experience in the heavy machinery field. H-P-M's reputation for dependability and performance in this field is unmatched, has a complete line of hydraulic equipment for both large and small systems. Write for our latest catalog.

THE HYDRAULIC PRESS MFG. COMPANY

A Division of Koehring Company, Mount Gilead, Ohio, U.S.A.



Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card-page 19

Precision Parts

New catalog outlines bobbin, washer, and other precision stock parts available for immediate delivery. Listed are properties of nylon, Teflon, and epoxy materials, product illustrations, and specifications on more than 500 parts. Maximum and minimum sizes and shapes are clearly defined for special parts made to specifications. 24 pages. Cosmo Plastics Co., 2339 W. 14th St., Cleveland 9, Ohio.

Circle 601 on Page 19

Limit Switches

Bulletin B-30 describes heavy-duty, metal-enclosed, precision snap-acting switches. Detailed descriptions, photographs, and dimensional drawings show method of installing and structural details. Force and movement specifications are tabulated for all switches. 4 pages. Unimax Switch Div., W. L. Maxson Corp., Ives Road, Wallingford, Conn.

Circle 602 on Page 19

Servo Motors

New catalog shows models and updated specifications of Size 8 and 11 servo motors. Catalog provides revised model numbers, complete electrical and mechanical specifications, outline drawings, and torque-speed curves. Two-page technical discussion of damping theory compares and evaluates the various means to achieve damping. 24 pages. Helipot Div., Beckman Instruments Inc., 2500 Fullerton Rd., Fullerton, Calif.

Circle 603 on Page 19

Recording Oscillograph

Photographs and specifications in Bulletin 5124 describe in full the operation of a new, low-cost, portable recording oscillograph. Simple method of loading paper is demonstrated in a series of photographs. Complete specifications are provided, as well as data on optional accessories available. 4 pages: Electro Mechanical Instrument Div., Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

Circle 604 on Page 19

Servo Amplifiers

Catalog S-1169 lists major products of a servo amplifier line for both military and industrial applications. Specifications and application data are included for a variety of units. Technical information on magnetic amplifier theory, servo applications data on closed-loop single and two-speed systems, and servo motor-amplifier combinations for units from 5 to 2500 w is

incorporated. 16 pages. Magnetic Amplifiers Div., Siegler Corp., 632 Tinton Ave., New York 55, N. Y.

Circle 605 on Page 19

Electrode Glands

Catalog 960 describes electrode glands which pressure seal electrical leads into systems operating from 0.005 microns absolute to 2500 psi at temperatures from —300 to +1850 F. Pictures of the various units are included, as well as data on dimensions and specifications. 8 pages. Conax Corp., 2300 Walden Ave., Buffalo 25, N. Y.

Circle 606 on Page 19

Pins and Studs

New two-color catalog describes the various types, dimensons, and fastening applications of solid Groov-Pins and grooved drive studs. Catalog describes materials used, drilled hole tolerances, shear strength, maximum torque, insertion forces, and horsepower transmitted. It also provides information on and illustrates the basic principle of grooved pins, and shows how they lock. Various types of drive studs are shown, along with some typical applications. Dimensional and other specifications are given. 12 pages. Groov-Pin Corp., 1125 Hendricks Causeway, Ridgefield, N. J.

Circle 607 on Page 19

General-Purpose Plastics

"Quality Plastics for Quality Products" briefly describes many general-purpose resins, latices, and compounds. Present uses for the product are discussed, together with suggestions for new uses. Characteristics and processing of Hi-Temp Geon are discussed in the booklet, as well as physical properties of Abson materials, Estane polyurethane materials, and Polyblend 503H. 20 pages. B. F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio.

Circle 608 on Page 19

Drafting Aids

Total of 763 timesavers for draftsmen are listed in new catalog. Included are tapes, templates, symbols, spaced lettering, planning boards, and chart accessories. Illustrations and price list are incorporated. 28 pages. Chart-Pak Inc., Leeds, Mass.

Circle 609 on Page 19

Printed-Circuit Connectors

New folder describes a complete line of one and two-piece multiple connectors for printed-circuit boards. Detailed lists of the features of both the one and two-piece AMPin-cert connectors are given. Line drawings of each of the five types of snap-in contacts are shown, with descriptions of the design features of each. Cut-away drawings of the variety of connector housings available are also provided. Description of the solderless-termination technique for applying the contact directly to the wire end is provided. 6 pages. AMP Inc., Harrisburg, Pa.

Circle 610 on Page 19

Line Strainers

Line Strainer Guide J-LS brings together many facts needed by those who use or specify strainers. It illustrates steam and liquid units available in aluminum, stainless steel, cast iron, bronze, and cast steel. Guide also contains strainer tips for better performance, recommended mesh to use, and complete engineering details including features, photographs, dimensions, mesh availability, and particle-retention capability. Charts showing ratios of screen open area to inside pipe area for all sizes and screen mesh are incorporated. 4 pages. OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

Circle 611 on Page 19

Servo Development Kit

Bulletin 105 describes Size A servo development kit, consisting of a permanently packaged group of standardized servo-mechanism components from which a variety of mechanisms and gear trains can be assembled. Complete list of all parts included in the kit is provided. 2 pages. Precision Mechanisms Corp., 577 Newbridge Ave., East Meadow, L. I., N. Y.

Circle 612 on Page 19

Magnetic Disc Brakes

Bulletin 605 gives information on a complete line of magnetic disc brakes. Many series are listed and pictured, together with complete engineering and dimensional information. Section on brake selection is included in the booklet. 8 pages. Stearns Electric Corp., 120 N. Broadway, Milwaukee 2, Wis.

Circle 613 on Page 19

Tracing Paper

Tissue-thin, natural tracing paper, Banknote, is described in new pocket-sized folder. Advantages are pointed out, and processing is described in detail. List of sizes and thicknesses available is included. 4 pages. Keuffel & Esser Co., Third & Adams Streets, Hoboken, N. J.

Circle 614 on Page 19

Stainless-Steel Fasteners

"Stainless-Steel Fasteners for Industrial Applications" is a pocket-sized questionand-answer guide to industrial applications of austenitic stainless-steel fasteners. Folder reviews in capsule form the main features of the austenitic stainless family, and the ferritic and martensitic series are also reviewed briefly. Listing of the company's products available in stainless is given. 6 pages. Standard Pressed Steel Co., Box 102, Jenkintown, Pa.

Circle 615 on Page 19

Drafting Machine

Model 3300 drafting machine is described in new bulletin. Special emphasis is given to 20-in. arm model which covers a drawing area to 34 x 44 in. Specifications for the 16, 18, and 20-in. models are included, together with a section on scales available for the machines. 4 pages. V. & E. Mfg. Co., 766 S. Fair Oaks Ave., Pasadena, Calif.

Circle 616 on Page 19

Filter Cartridges

Bulletin MW-100 describes new Micro-Wynd disposable filter cartridges for filtering plating solutions, alcoholic beverages, diesel fuels, and chemical process streams. Manufacturing process involves interweaving a separate filtering medium between structural spiral windings on a perforated-metal core. Performance advantages, test reports, micron densities, fluid compatibility, and other specifications are included. 4 pages. Cuno Engineering Corp., 80 S. Vine St., Meriden, Conn.

Circle 617 on Page 19

Flexible Metal Hose

Revised catalog covers flexible metal hose used in a variety of applications. Many photographs are used to illustrate the uses for the various types of hose. Cross-sectional drawings, photographs, and tables provide all dimensional data. 38 pages. Pennsylvania Flexible Metallic Tubing Co. Inc., Lincoln Highway, Paoli, Pa.

Circle 618 on Page 19

Trimming Potentiometers

Brochure 6 summarizes key information on Trimpot, Trimit, and Twinpot leadscrew and worm gear-actuated potentiometers. Basic specifications such as terminal types, resistance ranges, end settings, tolerances, power ratings, operating temperatures, sizes, and prices are included for each of 13 models. Cut-away drawings illustrate some of the outstanding features found in all models. 4 pages. Bourns Inc., 6135 Magnolia Ave., Riverside, Calif.

Circle 619 on Page 19

Air-Control Valves

Bulletin 60-1 on mechanically and manually operated air-control valves covers \(\frac{1}{4}\)-in. NPT, two-position, balanced-spool valves, normally closed or normally

open two-way, normally closed or normally open three and four-way styles. Three-page spread presents all model numbers, specifications, and operators in one easy-to-read chart. Standard accessories are also listed. 6 pages. Hoffman Valves Inc., 2360 W. Dorothy Lane, Dayton 39, Ohio.

Circle 620 on Page 19

Ball-Bearing Screws, Splines

Catalog 61-E, "Ball Bearing Screw and Spline Operation," provides data on basic principles, types, and applications of ball-bearing screws and splines. Book also contains design data, sample problems, and information on lubrication, size ranges, critical speeds, finishes, and mounting methods. Illustrations, dimensional drawings, tables, and charts provide design data. 24 pages. Saginaw Steering Gear Div., General Motors Corp., Saginaw,

Circle 621 on Page 19

Digital Recording Systems

Applications for digital type-recording techniques are described in Brochure DD-7. Among applications described are communications, filing, media conversion, acquisition and reduction, and high and low-speed sampling. Functional and block diagrams are included. 20 pages. Industrial System Div., Minneapolis-Honeywell Regulator Co., 10721 Hanna St., Beltsville, Md.

Circle 622 on Page 19

Packaged Controls

Bulletin GEA 6334A describes Pan-A-Trol panels for use with machine tools, textile machinery, pumps, materials-handling equipment, presses, air conditioners, agricultural machinery, and similar equipment. Publication explains product features, and tells how panels are designed for specific control needs. Photographs show various devices used in the packaged control units. 8 pages. General Electric Co., Schenectady 5, N. Y.

Circle 623 on Page 19

Laminated Plastics

Illustrated catalog describes complete range of laminated plastic sheets, rods, and tubing. It offers information on standard applications for laminates, and suggests many new uses. Technical data include Panelyte and NEMA grades; colors, finishes, size, and thickness ranges; strength, density, water absorption, impact strength, and power factor; insulation and arc resistance; dielectric properties; special features of laminated plastic sheets, rods, and tubing. 18 pages. Dept. WMG, Panelyte Div., St. Regis Paper Co., Trenton 8, N. J.

Circle 624 on Page 19

Copying Equipment

Bulletin X-313 on Xerox copying equipment illustrates and describes the complete line of xerographic copying and offset-master-making equipment. It suggests numerous applications that are possible with this process. A section is devoted to attachments and other accessories

which further increase the versatility of the equipment, and list of everyday uses is provided. 16 pages. Haloid Xerox Inc., Dept. X313, Rochester 3, N. Y.

Circle 625 on Page 19

Temperature Chambers

New folder describes 1 to 10 cu-ft temperature chambers available for applications where temperatures from -150 to +300 F are required. The low-cost mechanical units are pictured, along with accessories and special controls. Specifications are provided for the chambers. 4 pages. Cincinnati Sub Zero Products, 3930 Reading Rd., Cincinnati 29, Ohio.

Circle 626 on Page 19

Small Cylinders

Bulletin 0230-B1 provides concise engineering data and specifications on maximum 200 psi Series S Midget-Air cylinders. Both universal mounting and nose-mounting models in 3/4, 1, and 1½-in. bore sizes with standard strokes to 12 in. are fully described. Four basic mountings are inherent in the design, providing versatility by choice of optional mounting attachments. Cutaway diagram points out internal and external features of the units. 4 pages. Hannifin Co., Div., Parker-Hannifin Corp., Dept. 116, 501 S. Wolf Rd., Des Plaines, Ill.

Circle 627 on Page 19

Nylon Shapes

New brochure gives data on nylon stock shapes available, charting physical properties of four grades of Cadco nylon. Available sizes for rod, plate, sheet, string, and tubing are listed, and typical applications are illustrated. Data on moisture conditioning, machining, bonding, welding, and coloring of nylon parts are given. 8 pages. Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich.

Circle 628 on Page 19

Rupture Discs

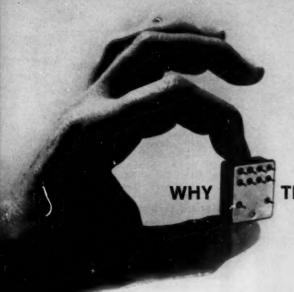
Data on Impervite rupture discs is included in new catalog. Separated into ten sections, it covers dimension standards on four types of discs, venting capacities, gasket sizes, bolt-torque specifications, and installation procedure. Photographs, drawings, and tables are used to illustrate the types and provide dimensional data. Engineering Dept., Falls Industries Inc., Solon, Ohio.

Circle 629 on Page 19

Valves and Couplings

Four new product data sheets describe a cryogenic control valve for use with helium; a two-way, coaxial, shut-off valve; a hydraulic-system bleed valve; and a pull-away coupling. All are designed especially for the aircraft and missile industries. Units are pictured and described, and specifications are given for each. Sheets are designated Forms 401, 401-00011, 403, and 406. 5 pages total. Special Products Div., Weatherhead Co., 300 E. 131st St., Cleveland 8, Ohio.

Circle 630 on Page 19



THIS IS A BETTER LATCHING RELAY

Better? Yes, in several ways. Bifurcated Contacts, for example, give improved reliability, especially in dry circuits. Contacts will not open during vibrations of 30Gs, 55 to 2500 cps. A special method of sealing cover to base eliminates flux contamination of the contacts. And there are more. Here is Potter & Brumfield's newest member of a distinguished family of micro-miniature relays: the FL Series.

Expressly designed for printed circuit applications, this DPDT, 3 amperes (@ 30V DC) latching relay lies parallel to the mounting surface. Its height, when mounted, is only .485", thus circuit boards may be stacked closer. Mounting can usually be accomplished without studs or brackets, simplifying installation.

The FL will remain firmly latched in either armature position without applied power, a significant advantage where power is limited and long relay "on" times are required. This relay may be operated by:

- 1. Pulsing each coil alternately (observing coil polarity), or
- 2. Connecting the coils in series and operating from a reversing (polarized) source.

Write for complete information or call your nearest PaB representative.

FL SERIES SPECIFICATIONS

- Shock: 100 Gs for 11 milliseconds. No contact
- Vibration: .195", no contact openings. 10 to 55 cps. 30 Gs from 55 to 2500 cps.
- Pull-In: 150 milliwatts maximum (standard) at 25° C. 80 milliwatts maximum (special) at 25° C.
- Operate Time: 3 milliseconds maximum at nominal voltage at 25° C.
- Transfer Time: 0.5 millisecond maximum at nominal voltage at 25° C.
- Temperature Range: -65° C to +125° C. Terminals: Plug-in pins
- Dimensions: L. 1.100" Max.—W. .925" Max H. .485" Max. Hermetically sealed only.



SC 11 D



SCG 11 DC

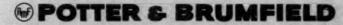




Other P&B micro-miniature relays include conventional and latching models in crystal cases with a wide range of terminals and mountings. All are made in a near-surgically clean production area under the exacting requirements of our Intensified Control and Reliability program.

PAB STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

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DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY . PRINCETON, INDIANA

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Barber-Colman motors offer wide range of power and speeds, plus long-life quality that adds extra product value, extra product economy









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a-c small motors

Wherever the application calls for a highly dependable small motor with unusual power or speed requirements (and all at low cost), you'll most likely find the answer at Barber-Colman. Geared types feature torques up to 300 lb-in. with speed ranges from 1/6 revolutions per hour up to 1500 rpm. Nongeared models are rated up to 1/20 hp at 2900 rpm. All are built to high-quality standards . . . for long, trouble-free service that eliminates bothersome costly maintenance of your product. Yet your cost per motor is surprisingly low.

LOW COST HIGH STARTING TORQUE

QUIET RUNNING
LONG-LIFE LUBRICATION

POROUS BRONZE OR BALL BEARINGS

PRECISION-HOBBED GEARS

QUALITY GUARANTEED

WRITE FOR NEW QUICK REFERENCE FILE on the complete line of Barber-Colman a-c small motors: unidirectional. reversible, synchronous. Up to 1/20 hp. With or without reduction gearing . . . open or enclosed types. Stator and rotor sets also available. Free engineering service.

BARBER-COLMAN COMPANY

Dept. M, 1273 Rock Street, Rockford, Illinois

Packaged Hydraulic Systems

Application of packaged hydraulic systems to solve a wide range of process control problems is the subject of Bulletin 1-5802. Bulletin includes numerous illustrations showing typical packaged hydraulic systems and installations. Advantages of hydraulics in process control are listed, and standard components are illustrated. 6 pages. Vickers Inc., Div., Sperry Rand Corp., Detroit 32, Mich.

Circle 631 on Page 19

Deposited Carbon Resistors

Results of a recently completed study into the performance and reliability of molded deposited carbon resistors are presented graphically in a new handbook. More than 20 charts and diagrams are reproduced, illustrating such variables as temperature cycle, short time overload, terminal strength, and load life. Section deals with resistor selection in equipment design. 28 pages. International Resistance Co., P. O. Box 502, Burlington, Iowa.

Circle 632 on Page 19

Speed Measurement Systems

Bulletin 2000, "Digital Speed Measurement Systems," illustrates instrumentation which provides an accurate, trouble-free method for measuring, indicating, or recording rotative motion. Proper selection and operation of magnetic and photoelectric pickups, electronic tachometers, and in-line readouts are discussed. Easy-to-read specification tables are coordinated with recommendations for the application, mounting, and coupling of each model. 6 pages. Electronic Div., Meriam Instrument Co., 10920 Madison Ave., Cleveland 2, Ohio.

Circle 633 on Page 19

Circuit Breakers

Design features of K-Don current-limiting circuit breakers are detailed in Bulletin 4300-1A. Bulletin carries a complete description of the equipment with information on selection and application, and a section on dimensions and guide specifications. Four tables provide data on protection of molded-case circuit breakers in switchboards, motor-control centers, panelboards, and bus duct systems, and also provide other performance data. 10 pages. I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia, Pa.

Circle 634 on Page 19

Electronic Equipment

Catalog 61 provides listings of over 5000 industrial motors and gear reducers, and over 25,000 industrial electronic parts available from stock. Included are blowers, cable, capacitors, speed controls, conveters, dynamotors, insulators, meters, motors, rectifiers, reducers, relays, resistors, sockets, transformers, and tubes. Items are illustrated, indexed, and clearly described. 176 pages. Write on company letterhead to Electro Sales Co. Inc., 50-58 Eastern Ave., Boston 13, Mass.

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Lock Washer

for high-torque uses and sealing applications

Folded-rim lock washer has a double-strength rim to meet the requirements of assembly work involving high torques and tensions. It can also be used in sealing applications to eliminate thread leakage under high pressures and temperatures to 500 F. Strength has been built in by turning back and crimping the ID, concentrating the load



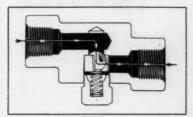
on a double-layer rim. Washer resists extreme fastening stresses, prevents slipping or creeping during tightening, and shows increased locking efficiency over conventional washers. Line is available to match screw sizes from 5/16 to 5/8 in. Shakeproof Div., Illinois Tool Works, St. Charles Road, Elgin, Ill.

Circle 635 on Page 19

Check Valve

for hydraulic or air system use

New hydraulic or air-system check valve incorporates a highly sensitive ball check in a forged body to provide full flow in one direction and instantaneous checking in the reverse direction. Ball is confined to close limits within the erclosure, and can move only in a vertical plane from its seat. Area of the ball is double the seat area. Pressure



applied over the ball area as it leaves its seat causes it to accelerate, providing rapid opening at low differentials without chatter. Large internal passages and unrestricted ports ensure maximum oil or air flow and minimum pressure drop. Body is a high-tensile-strength aluminum, steel, or stainless-steel forging. All internal parts are stainless steel. Valve is available in 1/8, 1/4, $\frac{3}{8}$, $\frac{1}{2}$, and $\frac{3}{4}$ -in. pipe or tube sizes. Operating pressures for aluminum are 3000 psi; steel and stainless steel, 5000 psi. Auto-Ponents Inc., 3001 Grant St., Bellwood, Ill.

Circle 636 on Page 19

Low-Temperature Bearing

for cryogenic service

Operating with a 300-lb thrust load, 45-mm bore bearing meets requirements of the field of cryogenics. Separator design utilizes Teflon-filled glass fiber, reinforced with stainless steel to provide minimum weight and coefficient of friction and to overcome excessive separator wear. Races and balls of 440C stainless steel, and design of internal geometry to minimize ball sliding and compensate for relative contraction rates, are important to suc-



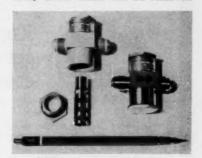
cessful operation of the bearing. Bearing Div., Industrial Tectonics Inc., 18301 Santa Fe Ave., Compton, Calif.

Circle 637 on Page 19

Miniature Fluid Filter

incorporates bypass valve to permit full fluid flow

Model P/N 1850 miniature fluidsystem filter, weighing only 2 oz, features in-line ports and an adjustable bypass. Port arrangement allows straight-through flow, minimizing pressure drop. Bypass ball valve incorporated into the unit permits full fluid flow in case of filter clogging; it can be adjusted to open through a pressure drop range of 20 to 100 psig. Designed for general use with liquids or gases, unit filters to 10 microns. Filtering element is stainless-steel mesh, 1½ sq in. in area, Filter mesh can be removed



from either end of the body. Filter can be assembled or disassembled without danger of wrong orientation of parts. Pyrodyne Inc., 11973 San Vicente Blvd., Los Angeles 49, Calif.

Circle 638 on Page 19

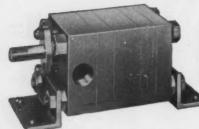
Indicator Light

incorporates a black shroud

Model 855S-DS panel indicator light features a black shroud which ex-

for pumps as individual as a fingerprint!





SPECIFY NORTHERN NITRALLOY PUMPS

Northern designs and builds quality into every pump. For each application, materials are selected with infinite care—gears with ground tooth form for perfect contact, correct clearances. Meticulous inspection at every stage in the manufacturing process assures efficient, economical, lasting service for even the most difficult pumping tasks under rugged conditions, indoors and out, year after year.

Northern Nitralloy Pumps are available in capacities from 1/4 to 146 GPM at pressures up to 2000 PSI. Within this range there is a pump as individual as a fingerprint — as "special" as you want it.

Write today for free catalog and engineering data.

Northern Ordnance Incorporated

Subsidiary of NORTHERN PUMP COMPANY

Minneapolis 21, Minnesota

Circle 477 on Page 19

WHEN YOU NEED HELP IN A HURRY-



Koppers coupling service cuts costly down-time

Not every coupling service need is an emergency. But it's the emergencies that really test a good organization. That's why Koppers maintains experienced field engineers and outstanding stock facilities throughout the country. In addition, if it's a Fast's Coupling you're replacing, we have a serial number and specific application history for every Fast's for easy reordering. And our modern manufacturing facilities have the

extra capacity to lick an emergency for special requirements.

Example: A modern windowless bank in Georgia was able to open for business as usual only because Koppers flew in a completed replacement coupling for its air conditioning unit. Elapsed time . . request phoned to Baltimore after 10 in the evening . . coupling arrived before 7:30 next morning.

KOPPERS COMPANY, INC., 401 Scott St., Baltimore 3, Md.



FAST'S COUPLINGS

Engineered Products Sold with Service

NEW PARTS AND MATERIALS



cludes light emission from the sides. It is suitable for computer applications, instruments, and panels. Unit mounts in $\frac{3}{8}$ -in. diam hole. It is also available in a two-color version which is colored when lit, and white when unlit. Color-Lite Div., Sloan Co., 7704 San Fernando Rd., Sun Valley, Calif.

Circle 639 on Page 19

Standard Shaft Assemblies

in monodirectional and bidirectional types

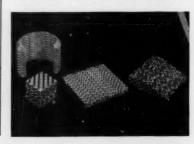
Some 180 different flexible shaft assemblies can be made up quickly from a stock of component parts—cables, casings, and end fittings. Assemblies are available in two types: Monodirectional, used basically for motor-driven or high-speed application to revolve only in one direction; bidirectional, used primarily for motor-driven, high-speed applications or where the cable is required to turn in both directions. F. W. Stewart Corp., 4311 N. Ravenswood Ave., Chicago 13, Ill.

Circle 640 on Page 19

Honeycomb Core Material

of cross-laminated, aluminum foil layers

Trussgrid honeycomb material displays high strength and excellent dimensional stability. Cross-laminated layers of corrugated 5052 alloy aluminum foil are used, corrugations of each layer forming a 90-deg angle with those of neighbor-



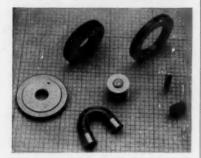
ing layers. Channels in alternate layers of foil run in the same direction, providing strength and rigidity in three planes. Material performs well in both light and heavy loadbearing applications. It can be shaped readily by roll-forming and crushing, and has excellent machining characteristics. Natural venting characteristics permit bonding with all types of adhesives. Several standard sizes are available. General Grid Corp., 713 Stokes Rd., Army Chemical Center, Edgewood, Md.

Circle 641 on Page 19

Miniature Bellows

in a wide selection of sizes, shapes, alloys

Precision instrument bellows and sensitive diaphragms are available in a wide selection of sizes, shapes, and proprietary alloys. New process



permits wall sections of 0.0005 to 0.005 in. in materials suitable for high-temperature, high-pressure, and nonmagnetic applications. Kinemotive Corp., P. O. Box 386, Huntington Station, L. I., N. Y.

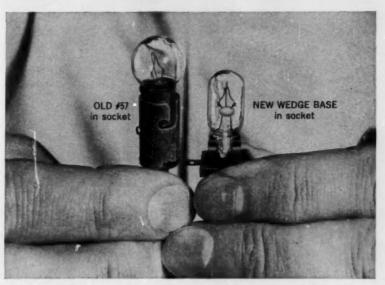
Circle 642 on Page 19

Digital Display Instruments

are contained in 2-in. diam sealed cases

Series 40-100 Microjuster control units incorporate precision gearing and a wide selection of rotating components for conveniently introducing heading, speed elevation, bearing, or other voltage settings into servo systems. Units are available with a wide selection of single and dual-speed synchros, potentiometers, or shaft encoders. They are contained in 2-in. diam MS33639 sealed cases, and the assemblies qualify to MIL specs. Counters are

NEW G-E "WEDGE" BASE" LAMP SAVES SPACE, SAVES MONEY, SAVES TIME, SAVES MANPOWER



The new "Wedge Base", all-glass, incandescent indicator lamp is an exclusive G-E development designed to replace the old #57 and other similar bayonet-based lamps. It's available in 6.3 and 12 volts. See below.

The Wedge Base saves space because, with its holder, it is considerably smaller than the old #57. It saves money because the holder and total installation costs are less. It saves time because the holder is easier to install and the lamp can be seated with just a push. And it saves manpower because installation can be automated and holders can be molded into plastic circuits. The G-E Wedge Base lamp can withstand ambient temperatures up to 600°F because it has no basing cement.

A major automobile manufacturer is already using G-E Wedge Base lamps; they're available in mass quantities. For more information write: General Electric Co., Miniature Lamp Department M-12, Nela Park, Cleveland 12, Ohio.

The Wedge Base is available in two ratings

G.E. Lamp No.	158	159	1	T
Circuit Volts : .	. 12	. 6.3	11	(0)
Amperes	. 0.24	. 0.15	(A)	1 1 1 1
Design Volts				
Rated Av. Life			ALA	1 11
at design volts .	.500 Hrs.	. *	0	0 16
Filament	. C-2V	C-2R	I II	TII
L.C.L	. 1/2"	. 1/2"	14	
Bulb	. T-31/4 .	T-31/4	A	200
Base Type	.Wedge .	Wedge	111	DC
Candlepower				
*In excess of 500			ALC:	
III excess 01 700	v 1113. at v.	o voits		- 04"-J

Progress Is Our Most Important Product

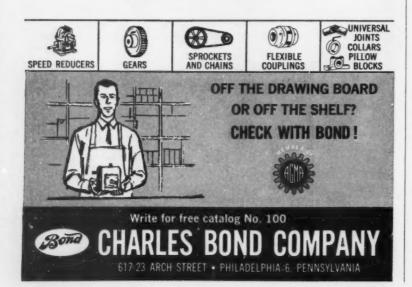




DESIGNED FOR THE DESIGNER

Bond Stock Power Transmission Equipment is routinely selected as integral components for new machine designs. Design experts find it saves time and money to check with Bond first before creating special equipment to solve a design problem. Frequently it develops that a Bond Stock Component answers the purpose without resorting to a new engineering approach, expensive dies and costly delay.

Should your situation demand innovation, Bond will be happy to manufacture transmission equipment to your specifications. Bond's almost three-quarters of a century in power transmission design provides a world of special experience at your service.





available in special configurations and calibrations, with red or white integral lighting. Balanced, long-life detent on the input knob facilitates making and maintaining settings. Backlash is reduced to approximately 2 min through use of AGMA Precision 2 gears and ABEC-7 ball bearings. Servo Development Corp., 2 Willis Court, Hicksville, L. I., N. Y.

Circle 643 on Page 19

Shaft Locks

for use on volume controls, coils, and capacitors

Two wrench-type Cambion shaft locks are brass per QQ-B-626a ½ hard, available in black-oxide finish or with heavy nickel plating. They are designed for use on volume controls, coils, and capacitors. Lock 2038 for ½-in. diam shafts is ¾ in. long with 11/32-in. hex locking nut and 11/32-in. hex collet (¼-32 thread). Lock 1774 for ¼-in. diam shafts is ½ in. long with ½-in. hex locking nut and 9/16-in. hex



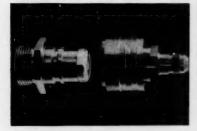
collet (3/8-32 thread). Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.

Circle 644 on Page 19

Quick-Disconnect Coupling

small, lightweight unit has push-pull action

Series 17 Trigger-Lock coupling is for applications requiring minimum leakage on disconnect and minimum entrapment of air or other foreign matter on connect. The small, lightweight unit has fast, automatic push-pull action for coupling and uncoupling; high reliability over a broad temperature range; low pressure drops; and long service life. It incorporates flush-face poppets and fast-acting, self-locking collar. Basic unit meets military specification MIL-C-25427. Actuation is open manual, close automatic trigger; coupling can be adapted for remote or breakaway actuation, Size of standard models ranges from 1/4 to 11/4 in. Sizes 1/4 through 1 in. are proof-rated at 4500 psi, burst at 7500 psi. Size 11/4 in. unit is



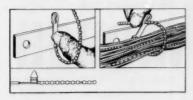
proof-rated at 900 psi, burst at 1500 psi. Jack & Heintz Inc., P. O. Box 6719, Cleveland 1, Ohio.

Circle 645 on Page 19

Plastic Wire Tie-Clamp

is chemically inert and heat resistant

Push-Button combination wire tiecable clamp cuts material costs and speeds assembly by eliminating separate cable clamps, mounting screws, and wire ties in many applications. Button snaps into any 0.250 to 0.256-in. hole, securely fastening tie to chassis or frame. Tie adjusts to 30 different sizes from 1/8 to 1-5/16 in. diam and can be opened and closed to add or repair wires without removing Push-Button mounting. Made from high dielectric polyethylene, tie-clamps are chemically inert and heat resistant, and are available in three



Circle 481 on Page 19→

LONG LIFE, THOMSON "Snap-In"

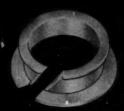
-BEARINGS of smooth, tough DuPont NYLON



Low Cost FLANGED Nyliner



Low Cost SLEEVE Nyliner



Low Cost DOUBLE-FLANGE Nyliner

COST LESS to BUY COST LESS to INSTALL ELIMINATE LUBRICATION

Additional Benefits:

- · CLOSE FIT
- · LONGER LIFE
- · EASILY INSTALLED
- · LESS SERVICING
- . SELF-RETAINING
- · RESIST CORROSION
- . LOW FRICTION
- RESIST POUNDOUT
- . DAMP VIBRATION
- . OPERATE IN LIQUIDS
- NON-CONTAMINATING
- . INSTANTLY REPLACEABLE
- · RESIST ABRASION
- NO FRICTION OXIDATION . MINIMUM SPACE
 - . SILENT OPERATION
 - . LIGHTEST WEIGHT
 - . REDUCED WEAR

Engineered to Solve Problems . . . Improve Products . . . Reduce Costs!

NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

Seven Standard Types available from stock, Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.

THOMSON INDUSTRIES, Inc.

DEPT. 4, MANHASSET, NEW YORK

-Manufacturers of BALL BUSHINGS . . . the Ball Bearing for Linear Motions and 60 CASE . . . Hardened & Ground Steel Shafting



HEINZE UNIVERSAL MOTORS

When you want power in compact series motors, Heinze Universal Mo-tors provide high starting torque, var-iable speed, reversibility and high output. Originally developed for sew-ing machines and office machines, they are extremely flexible in design for a variety of uses not requiring constant speed. Flat sided models are especially adaptable for limited space

Horsepower ratings are from 1/10 to 1/30. Load speed is 7,500 rpm. to 1/30. Load speed is 4,500 rpm, Standard voltage rating is 115V, AC/DC but motors are supplied for other voltages in AC or DC. Rotation is CW, CCW, or reversing. Optional mounting arrangements include tapped holes on flat side.

Send coupon for new catalog on Heinze Universal Motors — plus the complete line of Heinze sub-fractional horsepower motors and blowers.



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Please send new catalog on Heinze sub-fractional motors and blowers.
Name & Title
Company
Street & No
City & State

NEW PARTS AND MATERIALS

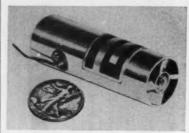
different colors, 51/2 in. long. Richco Plastic Co., 3722 W. North Ave., Chicago 47, Ill.

Circle 646 on Page 19

Miniature Blower

is 11/2 in, in diam, and weighs 3.5 oz

Miniature de blower, smaller in diameter than a fifty-cent piece, moves 10 cfm of air against 0.3 in. water back pressure. Blower is 11/8 in. in diam by $3\frac{1}{4}$ in. long, and operates on 27 v dc. Lower voltages can be used with different motor windings. Unit weighs 3.5 oz. Unit pictured utilizes Type VS motor, and is typically used for spot cooling



of critical components in a circuit. Globe Industries Inc., 1784 Stanley Ave., Dayton 4, Ohio.

Circle 647 on Page 19

Braided Packing

low-friction material is Teflon impregnated

Designated Style 5875, white asbestos braided packing contains more than 30 per cent Teflon by actual weight. Packing has widespread application on rotary and centrifugal shafts, valve stems and expansion joints, and reciprocating rods, plungers, and rams. It has a temperature range from -90 to +500 F, and low coefficient of friction reduces wear to the packing and to mechanical components during start-up and operation. Material remains unaffected by moderately destructive and corrosive minerals, acids, and caustics. Lattice Braid construction results in a strong, unified structure, independent of any single cover or layer to wear through and fail. Only moderate gland pressure is necessary to ready the packing for immediate



Pressure: to 540 psi.

Ten orifice sizes: 3/4" through 1/4".

Wide voltage range: standard with 115V. AC.; also 12, 24, 208, 230, 460V. AC. 50/60 cycle.

Body: brass bar stock or 18-8 stainless steel. All moving parts, stain-less. Seat disc, synthetic rubber. Sizes, ½" and ½" NPT. Both conduit and grommet types.

Underwriters' listed as a safety valve

Yes, "Master-mite" is the mighty mite of solenoid valves. Useable on a wide range of media including hydrogen, acetylene, etc. Works right in any position. Small, but with extra strength in the Marsh manner. Coils never overheat. Leak tight. Remarkably quiet.

Ask for special bulletin

MARSH INSTRUMENT COMPANY

Division of Colorado Oil & Gas Corporation, Dept. B, Skokie, III. Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas.

VALVES



operation upon installation. Packing is available in ½ through ½-in. sizes in 1/16-in. increments in either spool, reel, or ring form. Garlock Inc., 457 Main St., Palmyra, N. Y.

Heat-Setting Adhesive

resists water, chemicals, elongation, and stress

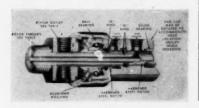
Pliogrip 22-4 is a synthetic, resintype, heat-setting adhesive which bonds plastisols to metals, glass, and ceramics. It also can be used to adhere rigid molded vinyl and plastic sheeting to other surfaces, creating bonds that will not break unless the plastic is torn. Material has excellent resistance to water, chemicals, elongation, and stress. It can be used with many different vinyl molding formulations, and is easily applied by brush, spray, roller, or dipping. Material has a light straw color. Chemical Div., Goodyear Tire & Rubber Co., Akron, Ohio.

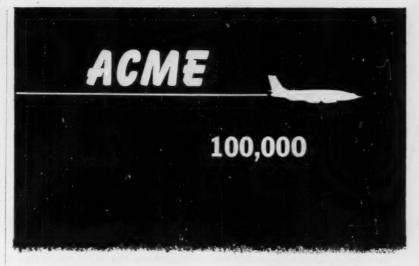
Circle 649 on Page 19

Rotating Union

provides leakproof, trouble-free performance

Model 1595 slow-speed, low-cost, rotating union is for installations which require a means to introduce two different media or the same medium through two different passages. It is rated at 150 psi air pressure, 1000 psi hydraulic oil pressure, with rotational shaft speeds to 200 rpm. It is applicable to rotating cylinders that require pressure











Conponation

Acme backs its quality Power Transmission Products with the best engineering service available in the industry. Even on short notice, Acme has its Engineers available to put their years of experience and technical knowledge to work in helping you solve a design, installation or any other chain drive problem you may have.

Acme has built its reputation on providing customers dependable service *before*, *during* and *after* the sale.

Wherever you are, whatever your problem, there's an Acme Engineer as close as your telephone, ready and willing to lend his assistance just for the asking. When your drive problems require service, call Acme.



Write Dept. 6-II for new ill. 100 page catalog with engineering section.



RELIABLE CHAIN DRIVES FOR ALL INDUSTRIES

ROLLER CHAINS, SPROCKETS, CONVEYOR CHAINS, FLEXIBLE COUPLINGS, ATTACHMENTS. (Special and Standard)

MCO ENCLOSURE SYSTEM

Aluminum



Semi-Custom

Provides Cooling, Mounting and Lighting in Modular Enclosures for Electronic Instruments in Any Installation

No one type of enclosure meets all environmental and physical demands. AMCO has developed 3 complete systems integrated into 1 system with interchangeable accessories, applicable for both commercial and military use.

CUSTOM...When space and appearance are critical ...16 ga. double-channel steel frames, based on increments of 191/6" widths, supports in excess of 3000 lbs. Multi-width panels and cowlings give single-unit appearance with series mounted racks. Mcets EIA Standards.

SEMI-CUSTOM... Heavy-duty, more internal clearance...14 ga. box-channel steel frames, 12 ga. gusseting provides exceptional rigidity both front-to-back and side-to-side. Frames based on $22\frac{1}{16}$ increments provides clearance for recessing 19 wide panels. Meets EIA Standards.

ALUMINUM...Unique! Meets any size... almost any configuration from 6 basic parts... 3 castings and 3 extrusions. Any size from 6⁸ to 20 ft.; any slope from 0° to 90° is standard. Mil Specs strength and material (6061-T6 extrusions and 356-T6 castings).

Amco manufactures all necessary blowers, chassis slides, doors and drawers, writing surfaces, cowling lights and other accessories. Check the extra savings you get thru Amco's combined-discount system of racks and accessories. PLUS FREE ASSEMBLY.

Amco is your one complete source of Modular Instrument Enclosure Systems and Accessories. Write today for catalog of complete specifications.



Factory trained representatives in principal cities of U.S. and in Canada.

AMCO ENGINEERING CO.



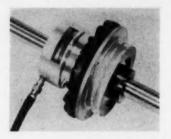
to either side of a piston. O-ring construction assures a leakproof seal for economical, long-lasting, trouble-free service. A ball bearing and an Oilite sleeve bearing are used to eliminate radial load on the O-ring. Deublin Co., 1919 Stanley St., Northbrook, Ill.

Circle 650 on Page 19

Air Clutch

mounts anywhere on shafts or motors

Model MW air clutch for applications to 10 hp has a unique mounting arrangement which permits attachment anywhere on a shaft or to a motor. Pictured is center-shaft mount. Unit is self-adjusting, and is both a clutch and motor sheave. No rotary joint is needed. Control



can be manual or automatic with special control-panel attachment. Clutch provides shockless starts without overheating. It hooks up with 3V belts, or can be pilot mounted for special sheaves and sprockets. Horton Mfg. Co. Inc., 1179-15th Ave. S.E., Minneapolis 14, Minn.

Circle 651 on Page 19

Photoelectric Controller

has sensing range from fractions of an inch to 8 ft

PE-601 transistorized photoelectric controller consists of a transistor amplifier and a power supply packaged in a plug-in unit measuring $2 \times 2 \times 11/2$ in. Light sources and cell are contained in $2 \times 11/4 \times 1/2$ -in. aluminum housings. System operates from 115 v ac, 50/60 cycles, with power consumption of less than 3 w total. Sensing range is from fractions of an inch to 8 ft. Integral sensitivity adjustment provides for wide range of applications



RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



Technical-ities By Fred E. Graves Fastening of "blind hole" joints

Holes which don't go all the way through a solid member must be tapped, of course. In shallow, small holes, in noncritical fastening, and in soft materials thread cutting screws work well and save time.

But fastening large flanges, pressure plates, heads and the like to costly castings needs more precise production. These holes are '4" diameter and larger, affect design strength.

THREAD FEFECTS

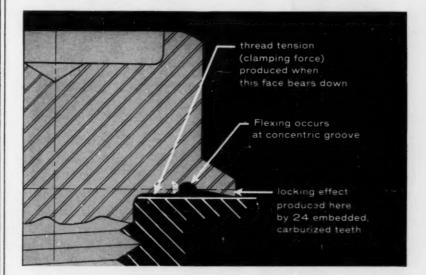
Such holes are coarse threaded. The coarse threads develop more thread strength than do fine threads, also take fewer turns in assembly. Studs go into the holes with an interference thread fit; hex screws with a simpler clearance fit.

Desirably, studs should all be driven to same depth and bottomed. Because of normal manufacturing differences, various mismatched high and low tolerances will cause studs to project unevenly. Assemblers often have to juggle. No such problem exists with hex screws. You just tighten to specified preload. And there's no double driving operation, as with stud plus nut.

STRENGTH OF BLIND JOINTS

Tapped holes behave like nuts. Their threads adjust elastically and plastically to distribute stress and develop high thread tension. Is this harmful in repeated disassemblies? Not at all. Hex screws have been installed 50 times in cast iron test blocks, then tightened to failure without damage to tapped holes.

Clamps like a hex screw Grips like an anchor



Tensilock® screws offer you the ideal combination of high clamping force and high locking power.

While a standard high strength hex screw can be tightened to a higher thread tension, its off-torque is less than its on-torque.

ANCHORED IN PLACE

The "Tensilock" screw features ratchet action teeth formed at an angle which will cut driving effort to permit you to utilize more of the full strength of screw. At equal driving torque, it not only develops 90% of the strength of a high strength hex screw but also takes 25% more torque to loosen than to tighten.

Because of the flange's concentric groove, it flexes, allows the screw to bear down solidly on its seat and develop a high level of thread tension. At the same time the teeth embed themselves, are aided in maintaining their grip by pressure of the spring-action flange.

MAKES GOOD FRICTION-TYPE JOINT

Clamping force from Tensilock fasteners is sufficient to prevent slippage of fastened members where holes are oversize or eccentric. Grip of the teeth keeps fasteners tight under conditions of vibration or cyclic temperature changes. RB&W

"Tensilock" Nuts also available. Write for Bulletin TL-2. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.



Registered and Patented

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; Son Francisco.

NEW PARTS AND MATERIALS

specialists

BHEW engineers are trained specialists who can save you time and money. BHEW products are noted for their dependable performance, long life and easy maintenance. Next time you have design and application problems, discuss them with BHEW—you'll profit more ways than one!

Brit W's single-acting General Purpose Cylinders (1500 psi Piston Style Series) are designed around standard components but custom-built to suit your application. They're available in a variety of mountings (pin eye is standard) with adjustable or non-adjustable rod ends, with or without rod ends.

DISCUSS YOUR DESIGN AND AP-PLICATION PROBLEMS WITH US!



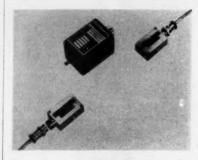
WRITE TODAY for free Hydraulic Cylinder Engineering Reference data. 78 dimensional basic designs for genaral purpose and special double- and single-acting cylinders. SAVE TIME!



- Basic Designs
- Superior Quality
- Specific Adaptations
- Application Engineering

BENTON HARBOR ENGINEERING WORKS, INC.

622 Langley Avenue • St. Joseph, Michigan



from detecting glass diodes to the detection of translucent sheets of paper and linen. Counting rate is up to 2000 counts per min. Unit can be light or dark-operated. Syracuse Electronics Corp., P. O. Box 566, Syracuse 1, N. Y.

Circle 652 on Page 19

Subminiature Terminal Block

features slotted nuts for fast assembly

Type 409-1802 subminiature terminal block is adaptable to aircraft electronic and electrical use where miniaturization is of prime importance and high vibration and shock conditions exist. Molded-barrier block measures 5/16-in. over-all width, and accommodates up to 21 terminals plus mounting holes in an over-all length of $4\frac{3}{8}$ in. Threaded stud and slotted-nut terminal is incorporated to facilitate



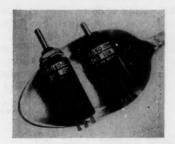
easier initial and maintenance connections. **Kulka Electric Corp.**, 633-643 S. Fulton Ave., Mt. Vernon, N. Y.

Circle 653 on Page 19

Miniature Potentiometer

has resistance range from 50 to 200,000 ohms

Model 160 miniature, ten-turn precision potentiometer, in an anodized aluminum housing, has a standard linearity tolerance of ±0.5 per cent. Special linearity tolerances to



±0.05 per cent can also be furnished. Terminals are mounted on the rear housing lid and protrude from the end, providing a true 1/2in, diam unit without projections. Mechanical stops withstand a 20 oz-in. force. Standard resistance range is 50 to 200,000 ohms ± 5 per cent, and operating temperature range is -55 to +125 C. Power rating (40 C ambient) is 2.5 w. Maximum starting torque is 0.75 ozin., running torque, 0.5 oz-in. Model is available in either bushing, screw, or servo mount. Spectrol Electronics Corp., 1704 S. Del Mar Ave., San Gabriel, Calif.

Cicle 654 on Page 19

Solenoid Valves

hold operating position until energized

New solenoid valves meet the requirements of military specification MIL-S-901B, and are approved for use on high-impact, shockproof equipment in hydraulic and air services. They hold operating position until energized, even though subjected to 400 g. Designed around the Lo-torq principle, valves are two-position, direct-acting units. They are available for service to 4000 psi with two solenoids, or to 2000 psi with one solenoid and spring return. Lo-torq seals wipe





GEARBELT DRIVES

GEARBELT ADVANTAGES:

- A POSITIVE DRIVE. No slip, creep or backlash.
- > STEEL CABLE strength member will not stretch, needs minimum take-up.
- FREEDOM from high initial belt tension. Reduces bearing loads, increases life.
- COMPACT. Gearbelts permit smaller pulleys, shorter centers, narrower belts.
- LIGHTWEIGHT. High horsepowerto-weight ratio.
- LESS HOISE. No vibration, no chatter.
- LESS HEAT because virtually no friction.
- split taper bushing grips pulley on shaft with vise-like pressure. Quick, easy mounting and removal.

Here is a versatile new drive that provides high mechanical efficiency plus the inherent flexibility of belts. Browning Gearbelts engage matching pulleys with the positive action of gears, yet without their disadvantages. They eliminate metal-tometal contact, lubrication, vibration, chatter. Require minimum maintenance.

Browning Gearbelt Drives provide costsaving advantages in scores of applications, particularly those which require high capacity in limited space, or freedom from stretch and take-up. Ask your Browning distributor for complete information, or write us for Catalog GB-201.

Browning Manufacturing Company Maysville, Kentucky

Browning... OUR 75th YEAR



the sealing surfaces clean as they slide across the disc. Seals are dynamically loaded to reduce torque. Subplate mounting permits removal of a valve for servicing without disconnecting lines. Republic Mfg. Co., 15655 Brookpark Rd., Cleveland 35, Ohio.

Circle 655 on Page 19

8

Small Bellows

thimble-size unit is lightweight

Sensitive bellows is available for use in a force balance or closed-loop pressure transducer. Bellows, about the size of a standard thimble, is



a lightweight unit which provides high reliability for close dimensional control, accurate pressure response, and long life. Metal Bellows Corp., 3031 Mica Lane, Wellesley, Mass.

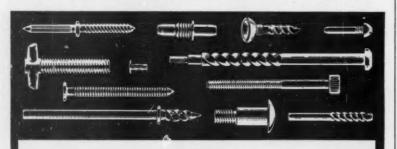
Transmission

5-hp unit provides almost instantaneous reversing

New 5-hp transmission, Electromission, provides high-speed positioning, reversing, and sequencing of loads for industrial servo systems and automated systems using card or tape control. Unit provides reversing within 0.2 sec under the most severe conditions. Transmission consists of an input and an output shaft, connected through either a gear drive or a chain drive, depending upon the status of two opposing electromagnetic clutches. Features and advantages include builtin amplification, low power requirements, and output speed choice. Transmission controls large amounts of power through use of very small control signals. Rated 5 hp at 1750 rpm, unit transmits torques in excess of 250 lb-in. under transient conditions; capability under steady-state



Circle 489 on Page 19



Job-Designed Threaded Parts for Every Industry



Here is a fast, dependable, low cost, quality minded source of supply for JOB-DESIGNED threaded parts and fasteners of all types, in any metal, to fit your own particular assembly

problem. Recognize the fact that a fastener designed specifically to fill a seemingly complex assembly requirement can easily cost less than design modification to accommodate so-called standard rivets. Assembly costs are a very major part of manufacturing expense. Most of this is labor. The fastening medium itself is usually a minimum item. If a Job-Designed fastener makes assembly simpler and faster, permits the use of fewer fasteners,

allows the designer functional freedom and improves product efficiency, yours is a specifying job well done. All these possibilities are available when you come to hassall for design assistance and quotation on challenging, difficult or unusual rivets, threaded nails, drive screws and other cold headed parts. Short or long runs, pilot quantities, engineering counsel, over 100 years of intimate association with cold heading—and a deep appreciation and regard for the concept of value analysis—all are a part of the Hassall service to you.

Send for a copy of our latest catalog.

JOHN HASSALL, INC. MANUFACTURERS SINCE 1850

P. O. Box 2197 • Westbury, Long Island, N.Y.



conditions at any desired speed is 180 lb-in. Industrial Div., Airborne Accessories Corp., 1414 Chestnut Ave., Hillside 5, N. J.

Circle 657 on Page 19

Relay-Conversion Kits

for modifying relays quickly and easily

Thirty color-coded relay-conversion kits, together with an information chart, permit rapid modification of standard types of relays in the PM line to meet virtually any switching-circuit control requirement. Each kit is packaged in a cardboard box in one of ten different colors. Total of 24 different pole kits is available with types of contacts for virtually any application. To assure positive relay operation with maximum life, strength of the magnet coil must match the mechanical load on the magnet. Coil-application system enables selection of the proper coil for optimum operation of any particular relay. Section of



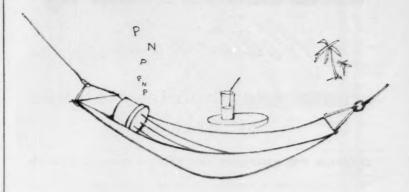
the chart includes complete magnet-coil application data. Clark Controller Co., 1146 E. 152nd St., Cleveland 10, Ohio.

Circle 658 on Page 19

Couplings and Connectors

are available for vacuum systems

New couplings and connectors employ Neoprene O-rings to provide convenient, positive vacuum connections with a minimum of extra com-



taking the overload off

The trouble with using fuses to protect transistors from short period overloads or fault currents is simple: the transistor is by far the better (and faster) fuse. It can also be called too much "thermal inertia" on the part of the fuse, but the transistor still ends up the same way.

As fate * would have it, a prominent relay manufacturer has now come to the rescue. We've devised a simple little 3terminal device that will prevent destruction of transistors by DC overloads. It's working in customers' equipment, and

- - operates in 1 to 5 milliseconds
- limits the transient, with a complete short circuit, to a maximum of 5 times the set value
- interrupts currents up to 5 amperes
- can be reset (locally or remotely)
 or designed to cycle
- will operate a local or remote warning light, buzzer, etc.
- can be supplied in a wide variety of set points

*and our New Business Program

- - operates within +20% of its set point
- - doesn't cost all outdoors

You do have to allow for the resistance this overload protector introduces into the circuit, but it's in the order of 1 to 5 ohms and the voltage drop is a few millivolts, less than one-tenth the voltage drop of the conventional circuit breaker.

To those who might question the economics of spending more than the transistor's cost just to protect it, keep the alternatives in mind. If the burned out transistor(s) lets a machine produce a carload of 4-foot yardsticks or causes a few hours of expensive down time, the protection is cheap. (Ever rented a computer?)

If you'd like some block diagrams of typical uses and an assortment of representative values and ratings, write to us, care of our Current Fault Division.

SIGMA

SIGMA INSTRUMENTS, INC. 89 Pearl Street, So. Braintree 85, Mass.

AN AFFILIATE OF THE FISHER-PIERCE CO.



single and double clutches or brakes

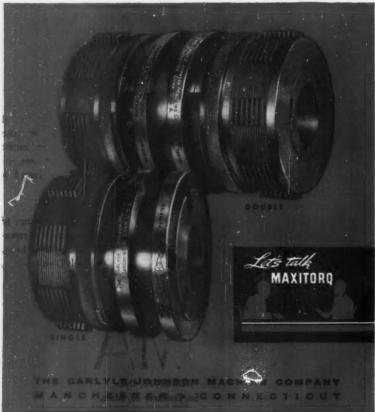
DESIGN PRINCIPLES OF THE 3 BASIC TYPES

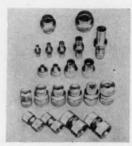
The Maxitorq Clutch is completely assembled on the clutch body and shipped ready to slip onto a shaft. Separator springs... an outstanding feature... assure the advantages of truly floating discs. Used between each pair of inner discs, they spread them endways with an accordian action so that light can be seen between all discs when the clutch is in neutral. The floating disc feature makes certain that there's no drag... no abrasion... and consequently no heat when the clutch is in neutral.

A locking plate on the disc end of each clutch (two on the double types) locks all discs against tension developed by the separator springs. Manual adjustment is made by raising the lock spring, then turning the adjusting ring to give the desired shifting pressure.

Note that assembly adjustment and take-apart are all manual...no tools required.

Standard Maxitorq Clutches are available in single and double types, wet or dry...also in pulley and cut-off coupling types. Capacities to 15 h.p. at 100 r.p.m. Write Dept. MD for bulletin today.





ponents, Line includes couplings for standard tubing, feed-through electrodes, connectors, gage ports, release valves, caps and nipples, and reducers. Central Scientific Co., 1700 Irving Park Rd., Chicago 13, III.

Circle 659 on Page 19

Electronic Counter

accepts input pulse as short as 120 mu sec

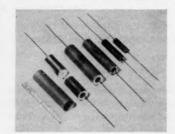
Count/Pak electronic counting system, designed as a completely packaged unit, uses a photoelectric pickup for sensing and actuation. It accepts an input pulse as short as 120 mu sec, and includes a special circuit to provide accuracy and high speed. Other features include a counting rate of 3000 cpm, instant reset, and life cycle of over 100 million counts. In addition to photohead actuation, unit works with a variety of pick-up devices, including proximity and influence switches, magnetic pick-ups, impact switches, and contactors. Electronic Controls Div., Veeder-Root Inc., Danvers, Mass.

Circle 660 on Page 19

Tantalum Capacitors

nonpolar units have 0.16 to 160 mf capacitance

Series N capacitors are made nonpolar by the back-to-back connection of two Series J solid-tantalum ca-



10.160

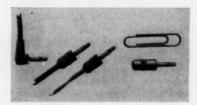
pacitors of identical value. Compact unit is then placed in a rigid plastic sleeve. Capacitors are available in capacitance values ranging from 0.16 to 160 mf, and in working voltages of 6, 10, 15, 30, 35, and 50 v for continuous operation at 85 C. Developed primarily for ac circuits, they can be used in dc circuits if the combined dc voltage superimposed on the ac voltage does not exceed the working voltage rating. Kemet Div., Union Carbide Corp., 11901 Madison Ave., Cleveland 1, Ohio.

Circle 661 on Page 19

Phone Plug

is for use with miniaturized jacks

Micro-Plug miniature phone plug is 1/25th the size of standard phone plugs, by volume. Designed for use with miniaturized jacks, it has applications in transistor radios, miniature electronic equipment, computing devices, and tape recorders. Five types of handles are available.



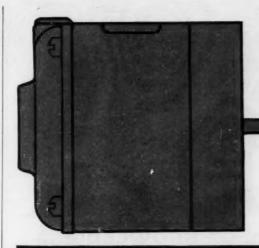
Construction of tip and sleeve is machined brass, bright nickel plated. Insulation is molded nylon, and sleeve terminal is tinned brass. Switcheraft Inc., 5555 N. Elston Ave., Chicago 30, Ill.

Circle 662 on Page 19

Tube and Pipe Fitting

withstands extremely low or high temperatures

Conoseal Union Fitting is available for small diameter sizes from ½ to 1-in. tube OD. Designed to withstand extremely low or high temperatures, and high pressures or vacuum where leakproof sealing is a requirement, all-metal fitting assures dependable sealing without leakage on applications with temperatures from -450 to +1500 F and pressures to 16,000 psig. The fitting is particularly suited for join-



Holtzer-Cabot Solves Fractional H.P. Motor Problems

12 MONTHS CONTINUOUS OPERATION at ambients up to 176°F.

A leading instrument manufacturer*, had the problem of continual motor failures after 2 to 3 months service in an instrument which required a minimum of one year's continuous duty in maintained ambients up to 80° C. (176° F.)

The thermostated, infra-red instrument in which the motor was to be used, required a 24-hour stabilizing period, dictating that no maintenance be performed.

To solve this problem, engineers from both the instrument company and from Holtzer-Cabot cooperated in the development of a motor with increased radiation area, plus reduced power input. This resulted in a motor temperature rise of only 20° C. as compared with 35° C. in the motors formerly used.

To provide positive lubrication, grease reservoirs were provided outside the bearing and a long-life stable grease suitable for high temperature was selected.

The result was a motor which has now been in successful operation for over 12 months without any motor failure or trace of bearing wear.

* Name on request

Write for Information! Holtzer-Cabot specializes in the design and manufacture of fractional horsepower motors for all types of applications. For complete details on Holtzer-Cabot motors for specific applications, and a copy of "Key Factors in Selecting AC Motors for Instrument Service" write direct or use Readers Service Card.



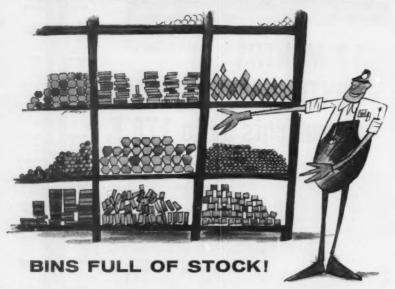
HOLTZER-CABOT

MOTOR DIVISION

National Pneumatic Co., Inc., Boston 19, Mass.



BEANS FULL OF KNOWLEDGE ...



If you use alloy steels in your operations, you will find Wheelock, Lovejoy a most useful ally. W-L offers you complete servicing of your alloy steel needs. There are seven strategically-located W-L warehouses, each of which is fully staffed by veteran metallurgists, ready to give you expert advice as to grades, applications, heat treating, etc.

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HEELOCK. OVEJOY & COMPANY, INC.

134 Sidney St., Cambridge 39, Mass. SERVICE CENTER





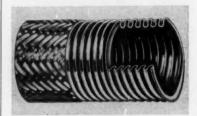
ing critical pneumatic, hydraulic, or fuel lines, cooling and heat-transfer lines, and pressure or vacuum lines. It can also be used as a transition joint to connect dissimilar metals. Normally all components are stainless steel to prevent corrosion. Marman Div., Aeroquip Corp., 11214 Exposition Blvd., Los Angeles 64, Calif.

Circle 663 on Page 19

Metal Hose

has high fatigue life and is easily cleaned

Hi-Flex metal hose is available in sizes from $\frac{1}{4}$ to $1\frac{1}{4}$ in., helically convoluted, braided, or unbraided. It incorporates improvements in flexibility, pressure ratings, fatigue life, and ease of cleaning. Hose is designed for exacting applications in the industrial field in both maintenance and original equipment. Formed with premium-quality tubing, hose has single longitudinal weld and smooth helical convolutions which make it easily cleaned to high levels for cryogenic and sensitive applications. Suggested



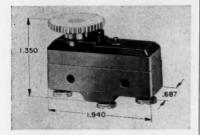
working pressures in the 1/4-in. size are as high as 4500 psi with static bend radius of 1.03 in. Flexonics Corp., Bartlett, Ill.

Circle 664 on Page 19

Adjustable Switch

has operating force of 12 to 32 oz

Adjustable differential travel is a feature of a new basic switch, designated 10BS210. Knurled wheel on top of the switch permits differential travel adjustment from 0.0025 to 0.007 in. Changing differential travel changes contact-break distance, pretravel distance, and operating and differential forces. Operating force varies from 12 to 32 oz and differential force from 2 to 15 oz. Release force remains at 10 oz regardless of differential setting. Switch is especially suited for controlling pressure controls or blower fans. Adjustment wheel permits extremely sensitive control of on-off cycles. Switch is rated at 20 amp at 120, 250, or 460 v ac; 3/4 hp at

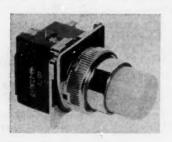


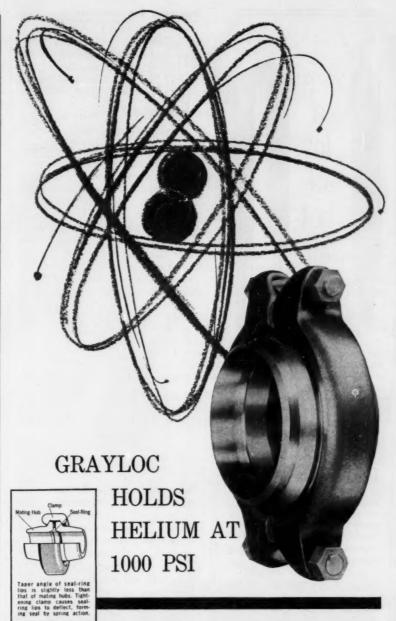
115 v ac; 1½ hp at 230 v ac. Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill. Circle 665 on Page 19

Illuminated Pushbutton

incorporates color-coded, molded-type transformer

Oiltight, illuminated pushbutton combines the functions of a pushbutton and an indicating light in a single unit. Unit incorporates a color-coded, molded-type transformer that is designed to be immune to voltage-surge lamp damage. Device can operate with multiple-contact blocks with any combination of normally open or normally closed contacts. Other features include base and one-hole mounting, functionally styled plastic lenses in red, blue, amber, green, clear, or white, and a positive mechanical "feel." Pushbutton is available for standard





In atomic energy service, GRAYLOC pipe connections have been specified to eliminate the leakage of helium at 1000 psi with working temperatures to 1000° F. This is just one of the many new applications for GRAYLOC found almost daily by design engineers.

GRAYLOC is an all metal assembly that can be quickly disconnected. It employs a pressure-aided seal ring that closes by spring action and is reusable. The entire assembly is smaller

and weighs less than ordinary, flanged connections.

Manufactured in standard stock sizes from 1" to 30", GRAYLOC connections can be made of corrosion resistant metals to meet any specifications. Special sizes can be provided on request.

Learn how GRAYLOC pipe connections can save you time, space and money. Write today for the new GRAYLOC catalog.



6007

P. O. BOX 2291

HOUSTON 1, TEXAS

Riverside 7-1240



VULCAN FINNED HEATERS

You get a lot of hot air with Vulcan Finned Strip or Tubular Heaters in such applications as blower type electric unit heaters; duct heating; unit convection heating; as oven or space heaters in dryers, pump rooms, etc.; baseboard room heaters — and many other applications.

And this is no "hot air": Vulcan Finned Heaters provide six times more effective heat transfer surface than similar non-finned elements. They are available in a wide range of sizes, wattage and voltage ratings, sheath materials, and terminal construction. Finned tubular heaters may be formed in a variety of hairpin bends.

Write for catalog and prices.



Circle 496 on Page 19

voltage ranges from 110 to 550-v applications. **Cutler-Hammer**, 328 N. 12th St., Milwaukee, Wis.

Circle 666 on Page 19

Air Regulator

is quick-adjusting unit

Model 2016 compressed-air regulator incorporates a lever and coarse adjusting screw in place of standard fine thread and tee-handle adjustment screw. A 180-deg turn of the lever adjusts regulator from 0 to 60 psi; a 360-deg turn adjusts it from 0 to 125 psi. Maximum primary (inlet) pressure is 300 psi and maximum secondary (outlet) pressure of standard unit is 125 psi. Regulator has two gage ports or



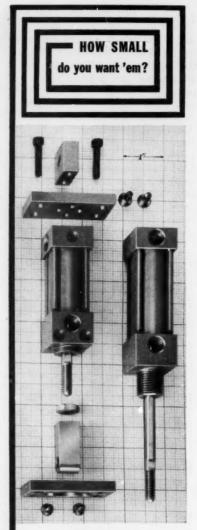
three outlets, is self-relieving or non-relieving, has balanced-valve construction and nylon-reinforced diaphragm. Internal metal parts are brass with a Buna N soft seat, and external metal parts are die cast Zamak. Quick-adjusting unit is 5 in. high and 3 in. across the body from inlet to outlet. Lever is 6 in. long and has black plastic knob on the end. Unit weighs $2\frac{1}{2}$ lb. Wilkerson Corp., 1646 W. Girard Ave., Englewood, Colo.

Circle 667 on Page 19

Hysteresis Synchronous Motor

tiny unit provides high efficiency

Size 8 hysteresis synchronous motor is only 0.96 in. long. It meets environmental requirements of MIL-E-5272, and provides constant-speed drive for computers and navigational devices. Designated Model A3361, the 400-cycle unit provides high efficiency and hunt-free synchronous rotation. Torque is 0.025



Hannifin offers new "Midget-Air" 200 psi cylinders in ¾", 1" and 1½" bores, double-acting or spring-return. Two basic models, "universal" and "nose-mounting." Universal models come drilled and tapped for mounting, or for use with any combination of the mounting attachments pictured. Delivery is off-shelf in standard strokes, shipment in ten days to specified stroke lengths. Want dimensions and prices? Write:





oz-in. and weight is 1.25 oz. Synchronous speed is 8000 rpm at 55 v. Single and double-phase designs are available. Total power is 5.1 w. Kollsman Motor Corp., Dublin, Pa. Circle 668 on Page 19

Electric Reset Counter

is six-digit unit having speeds to 1000 counts per min

Remote reset by pushbutton, mechanically operated switch, photoelectric, electronic, or other type relay is featured in CE-620 electric reset counter. The six-digit counter registers one count for each actuating impulse and is operated at speeds to 1000 counts per min. Unit can also be adapted for varied applications. Electric reset circuit requires 0.100-sec contact to make; total reset time is 2 sec. Unit is 6



in. wide, 4 in. high, and 51/8 in. deep. PIC Automation Controls Div., General Controls Co., 8062F McCormick Blvd., Skokie, Ill.

Circle 669 on Page 19

Solenoid Valves

have maximum pressure of 40 to 4 psi

Low-cost, direct-acting solenoid valves feature positive closing, full pipe-area orifices, solenoid protected and mounted in hinged electrical knock-out box, molded epoxy resin coils, and renewable composition

PRODUCT

HANSEN SYNCHRON TIMING MOTORS

CLOCK

using reset clock movements powered by Hansen SYNCHRON motors

MINNEAPOLIS-HONEYWELL REGULATOR

COMPANY incorporates Hansen SYNCHRON Clock Movements in its Indicating Clocks and Master Control Systems — for installation in schools, public buildings, in industry, or wherever accurate time must be maintained. Singledial Indicating Clocks are coordinated by Master Clock Programming, with automatic correction — to compensate for deviations caused by current fluctuations - available either on an hourly or 12-hour correction basis. Hourly correction resets the clock which may be from 55 seconds fast to 59 minutes slow depending on current fluctuations, at two minutes before the hour. The 12-hour correction occurs between 5:00 and 5:30 o'clock, automatically resetting clocks up to 12 hours slow.

HANSEN SYNCHRON CLOCK MOVEMENTS

were chosen by Minneapolis-Honeywell because of satisfactory power and dependability experienced by a previous supplier to the firm. Hansen SYNCHRON motors are connected to reset movements through a gear, clutch and cam arrangement. The clock systems operate with 60-cycle and 24-volt motors, on 115-volt current - generally most readily available on typical installations.

SEND TODAY for informative folder containing specifications and technical data on all Hansen SYNCHRON motors and clock movements.



HANSEN MANUFACTURING COMPANY, INC. RINCETON, INDIANA

THE FROMM COMPANY 5150 W. Madison, Chicago, Illinois H. C. JOHNSON AGENCIES, INC.

Rochester, N. Y. — Buffalo, N. Y. — Syracuse, N. Y. Binghamton, N. Y. — Schenectady, N. Y.

ELECTRIC MOTOR ENGINEERING, INC. Los Angeles, Calif. — (Olive 1-3220) Oakland, California

WINSLOW ELECTRIC CO.

New York, N.Y. — Essex, Conn. (SOuth 7-8229) Philadelphia, Penn. Cleveland, Ohio

Sweet's Product Design File



CLUTCHES and BRAKES

Both the Electomic Dry Magnetic Particle Clutch and Brake feature:

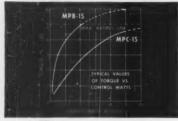
Fast response time — better than
 5 milliseconds ● Excellent linearity
 — an important factor in computers
 ● Few moving parts — to assure long life operation ● High torques ● Smoothness ● No chatter



Type MPC-15 Electomic Clutch transmits high torque .90 in.-lb., per watt of input power. • Speed: 5000 RPM max. • Output Inertia: 1.85 gr. cm² • Input Inertia: 21.5 gr. cm² • Weight: 8 ounces max. • Resistance: 140 ohms ±5% • Dielectric Strength: 500 VDC • Life: 100,000 clutch cycles min. • Response Time: Better than 5 ms. • Environmentally tested to meet or exceed Mil-E-5272C



Type MPB-15 Electomic Brakes are designed for high braking 2.5 in.-lb., per watt of input power. • Speed: 5000 RPM max. • Total Inertia: 2.0 gr. cm² • Weight: 8 ounces max. • Resistance: 300 ohms ±5% • Dielectric Strength: 500 VDC • Life: 100,000 braking cycles min. • Response Time: Better than 5 ms. • Environmentally tested to meet or exceed Mil-E-5272C

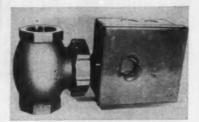


TE

For details write, wire, or call

TECHNOLOGY INSTRUMENT CORP.

531 Main Street, Acton, Massachusetts COlonial 3-7711 Brochure will be sent upon request. NEW PARTS AND MATERIALS



discs. Known as Type MDW, line consists of general-service valves in eight sizes from $\frac{3}{8}$ to $2\frac{1}{2}$ in. Valves are bronze, two-way packed type, spring loaded for positive closing. Maximum pressures vary from 40 psi in $\frac{3}{8}$ and $\frac{1}{2}$ -in. sizes to 4 psi for 2-in. valves. J. D. Gould Co., 4707 Massachusetts Ave., Indianapolis 18, Ind.

Circle 670 on Page 19

Fixed Capacitors

meet provisions of MIL-C-27287

Lectrofilm B capacitors, fixed plastic dielectric units using nonmetallic

tubular cases, now meet or exceed provisions of MIL-C-27287. Units are primarily designed for applications in missiles, computers, and other commercial and military equipment where long life and low failure rates are critical. Capacitors operate at ambient temperatures from -55 to 125 C. At 125 C, voltage ratings of 50, 100, 200, and 300 v dc are available, while at 85 C, ratings of 100, 200, 400, and 600 v dc can be obtained. Microfarad values for the units range from 0.001 to 1.00 mf with case sizes varying from 0.172 in. diam by 7/16



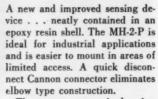
in. long to $0.548 \times 19/16$ in. General Electric Co., Schenectady 5, N. Y.

Circle 671 on Page 19





MH-2-P Magnetic Switch



The new epoxy resin housing results in less magnetic flux and

increased sensitivity. As a consequence, smaller magnets can be used and manufacturer reports a minimum magnetic field transient time of only 8 milliseconds is needed to activate the switch. Operating life is in excess of one billion operations.

Write For Bulletin MH-2-P



POST ELECTRONIC PRODUCTS

Division of Reid Brothers Company, Inc. 12 LOTHROP ST. / BEVERLY, MASS.

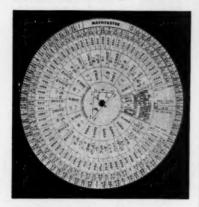
ENGINEERING DEPARTMENT

EQUIPMENT

Math Calculator

7-in. diam unit provides much data

Mathfaster calculator simplifies difficult and frequently used mechanical calculations by condensing commonly used information into a circular, 7-in. diam unit. Unit permits rapid addition or subtraction of fractions, and provides immediate access to such information as: Decimal equivalents of fractions; illustrated dimensions of round, flat, socket, or fillister head screws and nuts; tap drills and threads per inch of NC and NF screws; decimal size of letter and number drills; diagrammed formulas for solutions to triangles and areas



or volume of basic forms such as circles, trapezoids, and cones. Also included are: Gear and pulley calculations; gage number and thickness of standard sheet-metal sizes; and frequently used slide-rule conversion factors. Pierce Mathfaster Calculator, Box 837, Arleta, Calif.

Magnetic Tape Recorder

miniature unit weighs only 10 lb

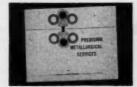
Portable magnetic tape recorder, Model PMR-500, is designed for precise acquisition of data under en-



Production capacity of ultra-thin metal strip and foil at Precision Metals Division of Hamilton Watch Company today is unmatched by any other plant in the world. This unique metals processing plant is now capable of an estimated annual volume of more than 18,000 miles of ½ x .000125" strip. thicknesses from .100" to .0001" Hamilton precision strip and foil is available in virtually any alloy cold rolled in a thickness range from .100" to ultra-thin .0001" in widths up to 10". Precise control of metallurgical and physical properties is maintained at all times.

comprehensive metallurgical facilities The Precision Metals Division is a completely integrated metals processing plant with facilities available for de-

velopment and production. Special alloys to your own specifications can also be furnished in the form you require. For information write today for Facilities Booklet MD-1 and Technical Data Sheets on such metals as Stainless Steel, Magnetic Alloys, Alfenol, Havar and Elinvar Extra.



HAMILTON

WATCH COMPANY / Precision Metals Division

H . Lancaster, Pennsylvania

Representatives COREY STEEL COMPANY • Chicago, Illinois FAGERSTA STEELS PACIFIC, INC • Los Angeles, California

NEW LINE OF UNIVERSAL JOINTS

For Applications Up to 1750 RPM.

Here is a line of high quality universal joints for all industrial applications. Joints are available in an extremely wide range of sizes in each of the following general types:



Standard and Heavy Duty Single Joints—Type D



Standard Double Joints—Type DD



Booted Joints Also Special Joints Engineered to Order

- .10 to 250 HP. at 100 RPM.
- Standard joints operate at speeds up to 1500 rpm. and heavy duty to 1750 rpm.
- Single joints operate through ε full working angle of 40° and double joints 80°
- Made of case-hardened fine alloy steels for light weight and exceptional durability
- Boot provides an effective means of proper lubrication for heavy load, high speed and high heat applications... eliminates dust . . . can be removed and repacked in field

Request recommendations for your application. Ask for Bulletin U-60 giving detailed information on complete line.



NAME IN UNIVERSAL

FLEXIBLE COUPLING CO

ENGINEERING DEPT. EQUIPMENT



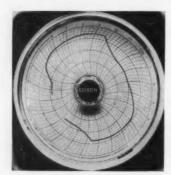
vironmental field or mobile conditions where low power and weight, reliability, and portability are major considerations. Measuring only 5 x $7 \times 10\frac{1}{2}$ in. and weighing 10 lb, unit handles data from dc to 100 kc at 30 ips, using AM and FM techniques. Any combination of record or reproduce totalling seven channels can be handled with 1/2-in. tape on precision 5-in. reels. Reels accommodate 900 ft of 1-mil tape, allowing 6 min of recording at 30 ips and up to 96 min at 1-7/8 ips. Tapes can also be reproduced on any standard laboratory-type recorders. Pacific Electro Magnetics Co., 942 Commercial St., Palo Alto, Calif.

Circle 673 on Page 19

Miniature Recorder

is only 3 in. deep

Miniature circular chart recorder is as small as a conventional meter and records any variable that can be converted to an electrical signal. Only 33/4 x 33/4 x 3 in. deep, it requires no pen, ink, or ribbon, the graph being printed by means of a stylus on pressure-sensitive paper. Simple gearshift mechanism in the form of a built-in, threeposition sliding lever provides a three-speed adjustment of the chart rotation. The 3-in. diam chart is



The quickest most practical way to put strong threads in soft materials the TAP-LOK® INSERT



IN SOFTER METALS AND PLASTICS... Has full V-form external threads to provide maximum locking torque and permit wide choice of mating hole sizes. Recommended for soft aluminum. zinc die castings, sand castings and plastics. Meets requirements of MIL-MS-35914.



H-SERIES

FOR HIGHER STRENGTH MA-TERIALS... Has heavy wall and truncated root external thread and three-hole cutting edges for hard-to-tap higher-strength materials and to meet MIL and other specs calling for Class 3B thread fit for gaging after installation.



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FOR WOOD . . . Has coarse pitch external threads offering maximum strength in combination with ability to be driven into thin sections without splitting them. For furniture, cabinets and other wooden parts where strong, permanent threads are needed, or that are frequently assembled and disassembled.

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GROOV-PIN CORPORATION

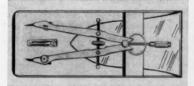
1130 Hendricks Causeway, Ridgefield, N. J.

extremely legible. Instrument records electrical voltage, current, or power, or any variable such as temperature or pressure, which can be converted into an electrical signal. Four basic types of meter movements are available to measure a wide range of dc and ac electrical quantities. McGraw-Edison Co., Instrument Div., Thomas A. Edison Industries, 61 Alden St., West Orange, N. I.

Circle 674 on Page 19

Bow Compass

has rapid center-wheel adjustment



New 6-in. bow compass is anodized aluminum for light weight and proper balance. It incorporates a steel center assembly for durability, with nickel spindle caps and supporting steel parts. Rapid centerwheel adjustment permits circles from ½ to 9-in. diam. Plastic tube holds the divider needle and shoulder needle points, in addition to compass lead and spare parts. Entire compass is enclosed in a protective vinyl case. Alvin & Co. Inc., 611 Palisado Ave., Windsor, Conn.

DC Power Supply

is regulated to 0.01 per cent in 7-in, panel height

Improved regulated DC power supply is rated at 0-36 v and 0-20 amp. Called Model CR-36-20, it is regulated to 0.01 per cent and requires only 7 in. of panel height. Operating features include remote sensing, remote programming, and dualling. Unit is readily converted to provide constant current by the addition of an external sensing resistor. Voltage adjustment resolution, by means of a ten-turn potentiometer, is closer than 5 mu. Supply is suited for laboratory bench use and 19-in. rack mounting. NJE Corp., 20 Boright Ave., Kenilworth, N. J.

Circle 676 on Page 19

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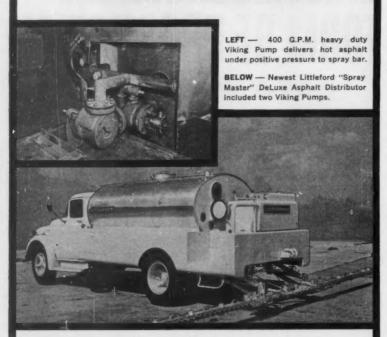
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ee Our Catalog in Sweet's Product Design File

THE ENGINEER'S

Library

Recent Books

Inertial Guidance. By Charles S. Draper, Walter Wrigley, and John Hovorka, Massachusetts Institute of Technology; 130 pages, 6 by 91/4 in., clothbound; published by Pergamon Press Inc., 122 East 55th St., New York 22, N. Y.; available from Machine Design, \$6.50 per copy postpaid.

This book is a treatise on the physical principles and engineering methods underlying the navigation and control of vehicles solely by means of signals from sensors. These sensors depend only on the inertial properties of matter for their operation.

Starting points are conventional navigation and Newtonian physics. Development proceeds from an examination of traditional navigation in terms of physics to interpretation of operations of navigation in terms of control theory. Problems include recent ballistic-missile guidance—where classification permits. Use of gyros in geometrical stabilization is given a unique treatment.

Statics and Strength of Materials. By Milton G. Bassin and Stanley M. Brodsky, associate professors of mechanical technology, New York City Community College; 354 pages, 61/4 by 91/4 in., cloth-bound; published by McGraw-Hill Book Go. Inc., 330 West 42nd St., New York 36, N. Y.; available from Machine Design, \$7.00 per copy postpaid.

Fundamental principles of mechanics and strength of materials are covered. Such topics as forces, moments, friction, centroids, inertia, and combined stresses are discussed. Calculus is not required to gain understanding of the material.

In this third edition, text material is supported by 134 solutions of sample problems, about 500 new figures, and new and revised supplementary problems. A list of formulas has been included for convenient reference.

Effective Work Management. By Milon Brown; 246 pages, 5½ by 8¼ in., cloth-

bound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; \$5.00

Guiding principles of effective work management, as they apply in specific job situations, are explained. Successful co-ordination of people, machines, materials, money, and production methods is discussed.

Analysis of management cycle covers meaning of management, planning and making decisions, executive action, management control, and applying the management

Government Publications

NASA Technical Notes. Copies of publications listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. D.

TN D-478. Lubricating Properties of Some Bonded Fluoride and Oxide Coatings for Temperature to 1500 F. By Harold E. Sliney, Lewis Research Center; 26 pages, 7% by 10½ in., paperbound, side-stapled; \$0.75 per copy. Solid-lubricant coatings, with good chemical stability in air to at least 1500 F, were formulated. Friction and wear data were obtained with hemispherical specimens sliding at 430 fpm against rotating diese coated with the experimental lubricants.

TN D-531. Experimental Investigation of the

mental lubricants.

TN D-531. Experimental Investigation of the Natural Frequencies of Liquids in Toroidal Tanks. By J. L. McCarty, H. W. Leonard, and W. C. Walton Jr., Langley Research Center; 26 pages, 7% by 10% in., paperbound, side-stapled; \$0.75 per copy.

Toroidal tank configurations applicable to missile and space-velucie liquid storage systems were oscillated to study natural frequencies of antisymmetric modes of contained liquids over a range of liquid depths and tank sizes. Data are presented in terms of dimensioniess parameters suggested by physics of the problem and by solutions for liquids in tanks having similar boundaries at the liquid surface.

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 151682. Physical and Mechanical Preperties of Columbium and Columbium-Base Alloys. By E. S. Bartlett and J. A. Houck. Battelle Memorial Institute; 63 pages, 8½ by 11 in., paperbound; \$1.75 per copy. Current information on physical and mechanical properties of columbium and columbium-base alloys is reviewed. Effects of singular and combined alloying additions on fabricability and low-and-high temperature strength are discussed.

PB 151682. Evaluation of Brairns and Ma-

strength are discussed.

PB 151915. Evaluation of Designs and Materials for High Speed-High Temperature Shaft Seals for Turbojet Engine Applications. By John J. Brenza, John H. Fuchsluger, Glenn F. Hyde, and Ernest J. Taschenberg, Koppers Co. Inc.: 88 pages, 8½ by 10% in, paperbound; \$2.50 per copy.

Materials were investigated to develop shaft seals that would operate for 1000 fm at 1000 F and a rubbing speed of 30,000 fpm. Material combinations found to be promising were evaluated as seals under conditions duplicating those existing in a jet engine.

PB 161499. Effect of Prior Green on the

those existing in a jet engine.

PB 161490. Effect of Prior Creep on the Mechanical Froperties of a High-Strength Heat-Treatable Titanium Alloy, Ti-16V-2.5Al. By Jeremy V. Gluck and James W. Freeman, University of Michigan Research Institute; 67 pages, 8½ by 10% in., paperbound, stapled; 32.00 per copy.

Oniversity of Michigan Research Institute; 9 pages, 8½ by 10% in., paperbound, stapled; \$2.00 per copy.

Effect of creep—to 2 per cent in 10 or 100 hr at temperatures from 600 F to 900 F—was determined on the tension, compression, and tension-impact properties of the alloy at room temperature or exposure temperature. Equipment used, procedures employed, and test results are discussed.

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Circle 506 on Page 19

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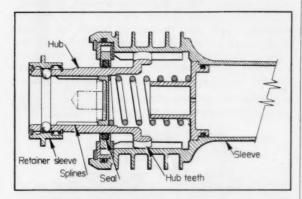
If this appeals to you not merely as a job but as the basis of a career, write at once (with all pertinent facts) to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

NOTEWORTHY

Patents

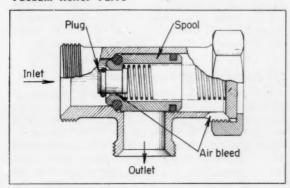
Quick-Disconnect Shaft Coupling

A gear-type shaft coupling permits a high degree of angular misalignment and large end movements between two shafts. Hub teeth are fully crowned, and the seal between hub and sleeve deflects to accommodate variations in alignment. The coupling is free to move axially to allow for different shaft lengths or to permit quick disconnection of the shafts. One shaft may be fastened permanently to the sleeve, while the other

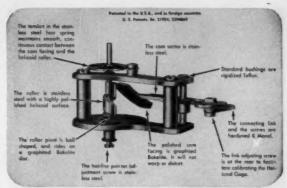


shaft is simply inserted into the internally splined hub. The retainer sleeve is then moved away from the coupling until the balls are forced into the radial groove in the surface of the shaft, locking the assembly in place. The sleeve is finned to provide maximum cooling for the coupling. Breather holes prevent pressure differential between the inside and outside of the coupling. Patent 2,959,943 assigned to Zurn Industries Inc., Erie, Pa., by Edward E. Allen.

Vacuum Relief Valve



A spring-loaded plug in a vacuum relief valve bleeds out any air in the system before fluid can pass through



Exclusive Helicoid movement provides <u>Sustained Accuracy</u> ...on the toughest jobs!

 Helicoid Gages have no gears, no teeth—wear is reduced to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Even when subjected to violent pressure pulsations or mechanical vibrations, Helicoid Gages stay accurate. Only Helicoid Gages provide all these advantages:

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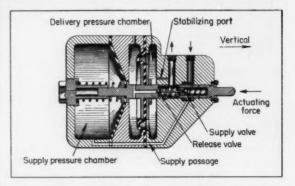


A DIVISION OF GAYLORD PRODUCTS INCORPORATED - 1918 S. PRAIRIE AVE., CHICAGO, ILLINOIS

the valve. When the pump is operated, air is forced through the axial air-bleed slot in the spool, and out through a bleed hole in the valve casing. When system air has been expelled, fluid pressure pushes the plug upwards until its O-ring seats against the boss at the bottom of the spool. A further increase in pressure causes the entire spool assembly to lift, allowing the passage of fluid through the outlet. Should the fluid pressure fall below a predetermined level, the spool falls, sealing the system against incoming air. Patent 2,960,996 assigned to Cherry-Burrell Corp., Chicago, Ill., by William M. Haselton.

Automatic Fluid-Pressure Regulating Valve

A self-lapping fluid-pressure regulating valve uses a diaphragm with a variable effective area to supply a predetermined delivery pressure with any selected supply pressure. When the unit is actuated, as shown, fluid under supply pressure normally flows directly from the supply port, through the supply valve, and to the exhaust port. The chamber at the base of the valve is always charged at supply pressure, while the stabilizing port allows the pressure in the delivery chamber to rise with any increase in delivery pressure.



When delivery pressure passes a predetermined point, the exhaust valve seat element is forced downward, closing the supply valve. This causes the supply chamber diaphragm to be stripped from its seat, exposing a portion of the area to supply and delivery pressures. The two pressures acting on the diaphragms maintain the preselected delivery pressure by producing a spring-action across the supply chamber diaphragm. Patent 2,958,337 assigned to Westinghouse Air Brake Co., Wilmerding, Pa., by Edward L. Halbrook.

Self-Adjusting High-Energy Brake

A hydraulic-brake actuating assembly compensates for both transient and permanent slack in the system, thus preventing dragging or locking. When the brakes are applied, the actuating piston moves upward to engage the brake lining with the drum. At the same time, a floating piston is moved upward until it engages a snap ring stop. Fluid trapped between the actuating and floating pistons acts as a compression link. If expansion or wear causes the drum to pull away from the shoe, line pressure moves the actuator up to keep the shoe and drum in contact. Since the

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Circle 511 on Page 19

Designer's Fact File from DENISON

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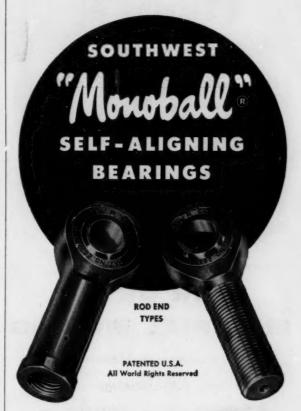
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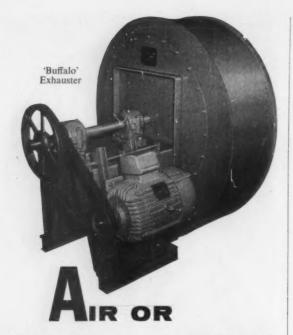
For types operating under normal loads with minimum friction requirements.

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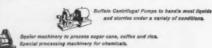
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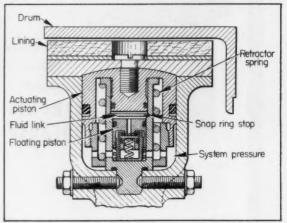
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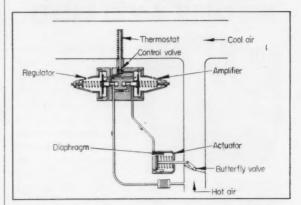
floating piston is held back by the snap ring stop, a greater volume of fluid flows into the fluid link. When the brake is released, the floating-piston valve snaps shut, trapping this fluid. Thus, the actuator piston



is not permitted to return to its original starting position, but assumes a new position to maintain a constant drum-to-lining clearance. Patent 2,961,074 assigned to B. F. Goodrich Co., New York, N. Y., by Burlin W. Oswalt.

Air-Mixture Temperature Control

A thermostat in the downstream portion of an air line controls the supply of hot and cold air to provide an air mixture of any desired temperature. When the mixture temperature becomes too high, the thermostat opens the control valve, permitting air to escape from the amplifier chamber. The resultant pressure reduction in the amplifier chamber closes the amplifier valve, cutting off pressure to the actuator diaphragm. The



actuator spring then closes the butterfly valve, restricting the supply of hot air. If the mixture becomes too cold, the control valve closes. The regulator valve then opens, allowing the passage of hot compressed air to the actuator chamber. Pressure on the diaphragm opens the butterfly valve, allowing the flow of hot air. Patent 2,961,163 assigned to the Garrett Corp., Los Angeles, Calif., by Raymond W. Jensen.

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- 2. Even the Heavy Duty SPIROL PINS in this socket-wrench universal joint don't cost more than other types of spring pins.
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Circle 515 on Page 19



Pot. #2.841, 174

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Mechanical **Features**

Sturdy die-cast housing with threaded hub

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Removable, "O"-ring-sealed cover with captive attachment

All wiring connections made with switch outside housing

Sealed actuators

Adjustable roller-arm or hand-operated actuators Roller-plunger actuators









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Circle 519 on Page 19

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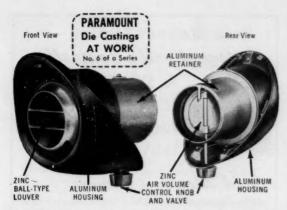
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Circle 520 on Page 19



PARAMOUNT QUALITY... chosen by Shakespeare Products for this automotive air conditioner part

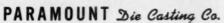
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Circle 521 on Page 19

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Circle 522 on Page 19



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Circle 525 on Page 19



A STANDBY ENGINE Automatically Controlled by SYNCHRO-START



64 SYNCHRO-START
CAN PROTECT YOU
FROM MAIN POWER
FAILURE

In A Matter of Seconds power can

be re-established by a standby engine equipped with Synchro-Start controls.

Since 1932 Synchro-Start has been manufacturing dependable controls that are operating standby power engines to provide protection for . . .

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These controls are in world-wide use plus a variety of other controls manufactured for specific engine operations.

For complete information on your requirement send engine data and desired operational control.

SYNCHRO-START PRODUCTS, INC.

Since 1932

8151 NORTH RIDGEWAY AVENUE . SKOKIE, ILLINOIS

Circle 526 on Page 19

molded Black Nylon screws and nuts

Insulate and Fasten without bushings, washers, etc. In Stock 2-56, 4-40, 6-32, 8-32, 10-32 and 1/4-20.





Black Nylon
"NyGrip"
cable
clips

Light-weight nonconducting support for wiring, tubing, etc. In Stock 1/6" to 11/2" Dia.

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SEND YOUR SKETCH, BLUEPRINT OR PART,

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DAYTON ROGERS
Manufacturing Company

MINNEAPOLIS 7C, MINNESOTA Circle 529 on Page 19

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For Hydraulic or Pneumatic Service

Here is the new BARCO SINGLE PLANE SWIVEL JOINT that swivels in one plane only. Ideal for use as a swivel connector:

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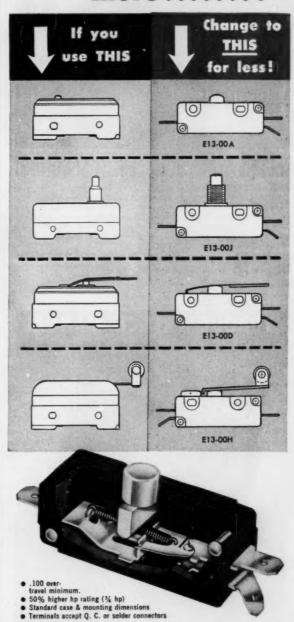
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TUBING, HOSE

DESIGN ENGINEERS:

why 75%

more?

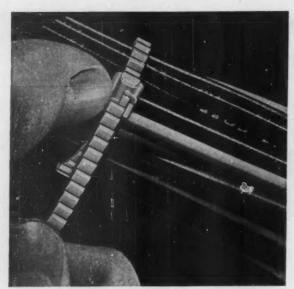


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U.L. rated 15 amp 125/250 V a-c ¾ hp V a-c, 1½ hp 250 V a-c



SECURE WIRE BUNDLES IN SECONDS!

Simply pull this modern self-locking nylon strap around your wire bundle, cut off the excess, and you have a positive-holding installation. No tying, no knots, no hitches to come loose with Bund-L-Tite*. It's the fastest, surest, most permanent way to secure wire bundles! Proved in aircraft and missiles under extreme loads, Bund-L-Tite* straps are made of tough, light-weight DuPont zytel, which meets MIL-P-17091. Write for free literature.

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*Trade Mark

Circle 532 on Page 19





- Choice of FIVE Basic Model Sizes — over 120 standard valves for unlimited modifications to specific needs.
- Control up to SIX Cylinders, single or double acting.
- Up to FOUR Standard

Control Positions — raise, lower, float and neutral.

- Available with Flange or Standard Mounting (3900 Valves only).
- Accurately Rated Capacities from 3 to 185 G.P.M. at 22 f.p.s. velocity.

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Circle 533 on Page 19

WHAT'S YOUR PROBLEM

PARTS? MATERIALS? COMPONENTS? FINISHES?

Perhaps one of our advertisers in this issue of MACHINE DESIGN has the solution to your dilemma. We'll be willing to bet that this issue contains information that is essential to answering your problem.

Fill out one of the yellow inquiry cards and send it to us. No letter or postage is necessary. We will forward your inquiry to the advertiser and he will reply directly to you.

Why not do it right now?

USE THE YELLOW CARD ON PAGE 19.

Manufacturers of over 85% of the torque wrenches used in industry



Wherever you require precision miniature headless slotted set screws, you can depend on Moore to meet your requirements to complete satisfaction. Prices are right. Delivery is fast. And quality is to the highest industry standards. Available in sizes #0 through #4 in a wide selection of materials, finishes, lengths and points.

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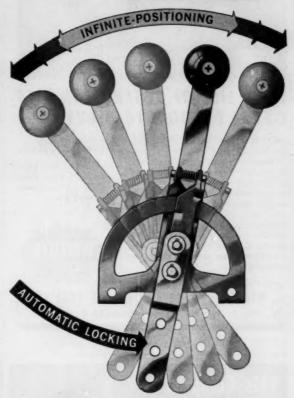
Circle 535 on Page 19



Why wait for delivery on spiral bevel gears? ARROW ships from a full stock of common sizes, in ratios: 1 to 1 • 2 to 1 • 3 to 1 • 3 to 2 and 4 to 3. Gear sizes of 1.000 to 13.000 pitch dia. Teeth are precision matched, case hardened and crown lapped. Sets are precision made, high speed tested.



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APPLICATION:

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The Adams Rite QUADRASTAT Control employs a selflocking principle which permits infinite-positioning through use of the primary handle, but absolutely prevents any creepage or change of setting due to vibration or "feed-back" forces acting through the driven or actuating lever.

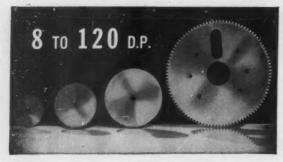
Uniquely engineered and comprised of only 5 main elements, the sturdy but lightweight QUADRASTAT is presently in trouble-free use on a wide range of control operations. It has been successfully incorporated into such diverse applications as tractor throttles, hydraulic valves, governors, air ducts, power boats, jet engines, and aircraft drag-brakes. The versatile unit may be manually, hydraulically, or motor controlled, and is available with handle, actuating lever, and quadrant mounted in various positions.

To learn how the QUADRASTAT can solve your control problem, write today for complete details and specifications, Department C-3.



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ACCURATE STAMPED GEARS by WINZELER are BIG savers of time and money. Single stampings are laminated to wide faces at savings up to 60%! Further economies are made possible by a BIG range of stock Dies. Modern new plant, methods, and equipment now greatly increase production speed, efficiency and economy! Send blue prints. Tell us about your needs today. No obligation.

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New list of WINZELERmade stock Gear Dies. Ask for it on company letterhead, please!



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Circle 538 on Page 19



provides perfect alignment and positive chain

adjustment. Mounted vertically on the "unitized" front trunnion stand, FUNK's unit takes up only a fraction of the space normally used in such applications.

Just one example of how FUNK MODULAR POWER UNITS may be combined in an unlimited number of arrangements - without special engineering costs.

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This is an opportunity to associate with a company recognized as a leader in the recreational field, and whose growth and stability has been outstanding. Positions offer good opportunities for technical advancement and longrange careers. Openings available at various levels from recent college graduates, Senior Design and Project Engineers to Engineers who have supervisory experience. New and modern engineering offices offer excellent work environment. The company is located in Western Michigan, "Heart of Michigan Vacationland" offering excellent opportunities for family recreational activities. Positions offer challenging work, attractive starting salaries commensurate with experience, along with excellent fringe benefits.

Send replies outlining education, experience, and salary desired, to A. J. Nelson.



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Circle 539 on Page 19

ENGINEERS AVAILABLE OR WANTED

WANTED: Assistant Professor of Engineering Graphics and Machine Design. Must have M. S. in Engineering and some professional design experience. Teaching experience desirable. Begin in Fall of 1961. Delightful surroundings: affable associates. Write to: G. S. Dobbins. Acting Head: Department of Engineering Graphics and Machine Design: University of Colorado: Boulder. Colorado.

WANTED: PRODUCT DESIGNER: B.S.M.E. or equivalent plus 8 to 10 years experience in design of precision products to provide technical direction to layout draftsmen and de-signers engaged in design of servomechanisms. Thorough signers engaged in design of servomechanisms. Thorough knowledge of drafting practices plus broad knowledge of machining and shop practices essential. Position is primarily technical and carries a minimum of supervisory responsibility. EXPERIMENTAL ENGINEER: M.E. or E.E. graduate with 1-3 years experience in servo component design and/or development. Position involves the design, test, and evaluation of assigned product developments. PROJECT DESIGN ENGINEER: Design, develop and evaluate hydraulic, pneumatic, and electrical systems in a variety of products for our newly created Industrial Division. Project of products for our newly created Industrial Division. Project of products for our newly created Industrial Division. Project responsibilities through production. Four to six years design background and understanding of production process, drafting, materials and costs. Creative, mechanically oriented engineer required. Our rapid growth has created these, and other opportunities in our engineering oriented Company located in suburban Buffalo. MOOG SERVOCONTROLS, INC., East Aurora, New York.

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AUTOMATION

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BPA



backtalk-

-File and Remember

A development engineer named Mayfield Lewis, who reads Machine Design in Pittsburg, Kans., has written to tell us how he finds information in past issues. Mr. Lewis types a condensed version of the contents pages on 4 by 6-inch cards and files them chronologically. He suggests that we print such a card with each issue, making it detachable for filing.

While we don't plan any immediate changes in our contents or index pages, we have a couple of suggestions for people who can't or won't type cards. First, there is the lazy man's version (ours) of the Lewis system—a file of

actual contents pages.

A bigger help is a reprint of the Annual Index, which, by coincidence, we are preparing now. The 1960 model of this vehicle was published in the December 22 issue. Look it over—if you'd like to have a copy for your very own, let us know via card, letter, or a note on the return post card, Page 19. It's free.

-Nomenclature News

Having just reported that we aren't changing our contents pages, we now wish to point out a few differences between this issue's and the last one's. Our editorial masthead, the permanent column on Page 4, has a new look, much to the satisfaction of several of those listed thereon.

Ben Hummel and Bob Stedfeld, who have shared associate managing editor responsibilities since 1956, now have individual titles. Ben is our new Executive Editor, and Bob is the

one-and-only Managing Editor.

The next two in the line-up, Leo Spector and Bill Miller, have been promoted to Senior Associate Editors. Leo joined us as an assistant editor in 1951 and was made an associate editor two years later. Bill celebrates his fifth anniversary here by adding "Senior" to his original title.

-For the Mechanisms-Minded

This issue contains the final installment of the series, "Mechanism Design," a group of articles which has brought a good many requests for tearsheets. Like it says on Page 133, these articles were based on a paper ("Four Cornerstones of Kinematic Design," by Thomas P. Goodman) given at the Sixth Conference on Mechanisms held at Purdue University.

Fifteen other papers besides Mr. Goodman's were presented at the 1960 Conference. Six more will appear in Machine Design, and all of them are available in reprint form. Copies can be obtained for \$2 each from Reader's Service Dept., Machine Design, Penton Bldg.,

Cleveland 13, Ohio.

-Ubiquitous Politicians

A friend of ours found himself sitting in an airliner whose take-off had been delayed for some time, so he asked the stewardess if she knew what was wrong. "Oh," she said, "there's just a little mechanical difficulty. It's the governor . . . or maybe it was the senator."

-Look for a Book

First of our double-headers for 1961, the January 19 issue will be in two parts: Part 1, the normal issue; Part 2, The Seals Book.

This reference book, the second volume in Machine Design's handbook program, will tell you almost everything you need to know about training seals, packings, and gaskets to do their jobs properly. The book is in two sections, a Design Data section and a Product Directory. In the first section, 14 chapters on dynamic and static seals tell how to select and apply. There is also a glossary of terms and a compilation of standards. The Product Directory, divided into eight sections according to different seal categories, tells who makes what.

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WANT TUBING IN A HURRY?

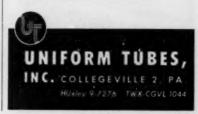


Need a small amount of fine seamless tubing in non-standard sizes for prototypes, experimental work, test models or pilot runs?

It's possible UNIFORM TUBES can supply it from stock-and give you immediate delivery at a reasonable, minimum-order charge.

UNIFORM TUBES stocks thousands of pieces of seamless tubing in a wide variety of materials-alloys of aluminum, copper, nickel, steel, glass-tometal sealing, etc.—in sizes from .625" to .005" O. D. and wall thicknesses down to .001". These pieces are overruns on regular close-tolerance production orders, economically made and stocked for your convenience on preliminary design or parts fabrication set-up work.

Write or phone your needs. We will help you if we can-anticipating your volume requirements later on.



SUPER-SPEED-SUPER-POWER



This special machine designed and built in the plant of Electro-Mechanical Products Co., clamps and pierces 3 holes in 20,000 pieces per day. It uses 3 Bellows Super-Speed Air Cylinders and a Bellows Air Motor. Set-up cost 1/3 the price of a punch press die.

This Super-Speed® Bellows Air Motor® is so powerful it can drive a 1/2" hole through 1/16" thick steel. The piston rod moves at a speed six to ten times the speed of an equivalent sized air cylinder.

That's why the Super-Speed is an ideal answer to many piercing, staking, forming, riveting, stamping, swedging and similar operations.

The Super-Speed Air Motor uses the basic

Bellows integral valving system with builtin operating and speed controls. Only one air connection is required which can be flexible hose. The directional valve may be either the low-voltage (8-12V) Electroaire® Valve or the finger tip control manual valve. One bore size, 2-1/2". Four standard stroke lengths, 4", 6", 9" and 12".

Write for Bulletin SS-5R. Address Dept. MD-161, Bellows-Valvair, Akron 9, Ohio.

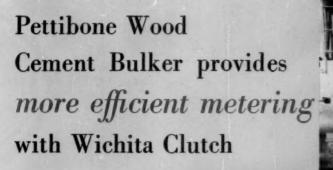
More than 200 Bellows-Valvair Field Engineers are at your service

Bellows-Valvair

AKRON 9, OHIO

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

206





Control of quantities of materials with Wichita Clutch is one of the most important keys to building good soil cement.

Whether you require clutching or braking for accessory equipment or rugged main power drives, it will pay you to investigate Wichita equipment. For suggested ideas, write for the Wichita Catalog.

for any difficult clutching or braking problem

CONTACT YOUR NEAREST WICHITA ENGINEER

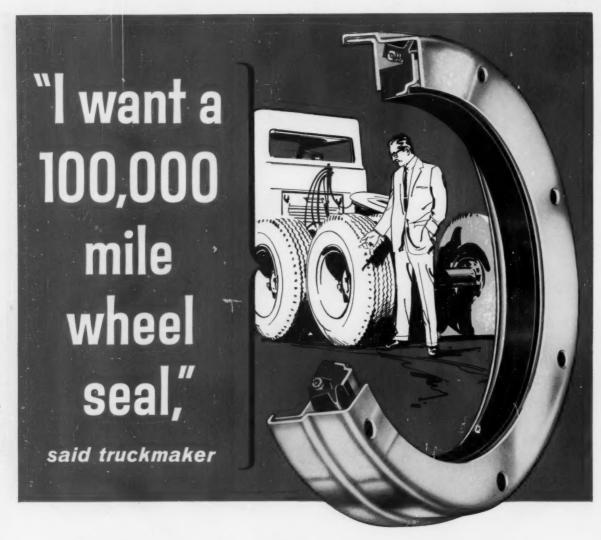
Clutch & Control Engineering Co., Livonia, Mich. Alli

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WICHITA FALLS

Write for Wichita General Catalog



"Here's Scotseal," said C/R

Premature wheel oil seal failure—often within the warranty period—was plaguing a major truck manufacturer. This was costly. One seal replacement took three hours labor and three hours tractor downtime—important money to the maker, dealer and buyer. Then C/R found an answer to the problem. A unique, new design called the C/R Scotseal* was submitted and tested . . . then tested again and again. First result: C/R Scotseals repeatedly ran 100,000 miles and more with no sign of failure. Second result: they're approved now for every truck tractor this manufacturer makes.

Just why does this seal go 100,000 miles? C/R developed

a special, ideal sealing surface and made it integral with the seal. The lip runs on this surface, not on the shaft or bore. In operation, centrifugal force creates positive, constant contact for leak-free performance. Also, the seal lip is completely encased and pre-lubricated, protecting it against damage in handling and assembly. This remarkable seal merits your consideration wherever high production runs are involved; where oil retention is difficult; and where equipment downtime and replacement costs are critical. The savings it can afford you and your customers may far outweigh the additional cost of this top-quality seal.

Write for your copy of C/R Scotseal* Bulletin SS-100.

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Offices in 55 principul cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
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C/R Products: C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears.



*Reg. U. S. Pat. Off.

